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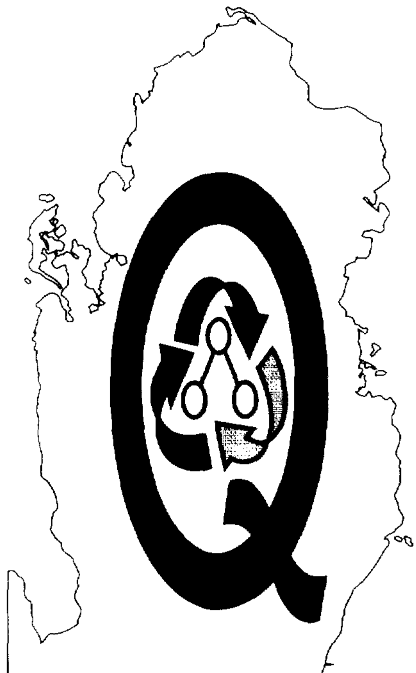

The Program and Abstracts

International Workshop on

ENVIRONMENTALLY DEGRADABLE POLYMERS: POLYMERIC MATERIALS AND THE ENVIRONMENT

Doha - Qatar, March 21-25 1999

International Workshop on Polymeric Materials and Environment

Organized by

ICS-UNIDO, Scientific and Applied Research Centre (SARC), University of Qatar, Qatar Petrochemical Company (QAPCO) and Qatar Industrial Manufacturing Company (QIMC).

THE PROGRAM AND ABSTRACTS

MARCH 21-25, 1999

Doha
State of Qatar

FOREWORD

The global issue of the plastic waste has promoted all over the world a great deal of actions tending to provide adequate answers and suggestions for minimizing the negative impact of the increasing production and consumption of plastic materials. Many companies in industrialized countries are working on developing a wide range of innovative packaging which offer real environmental benefits.

The production and consumption of polymeric materials for commodity and specialty plastic items have no face all the constraints an already operative or to be issued in the near future, dealing with the management of primary and post-consumer plastic-waste. In this respect the production of environmentally friendly (sound degradable) polymeric materials should be a strategic option among those available for the management of plastic waste. The competition with recently adopted technologies such as burial in landfill sites, incineration with energy recovery, and mechanical and chemical recycling is expected to be strengthened although it is predicted that all of them will coexist with an appreciable decrease of land-filling practice. These new degradable plastics should replace the conventional commodity plastics in those segments in which recycling is difficult or economically not feasible.

These aspects are of particular importance for developing countries and emerging economies, where the concept of waste management and rational production of plastics items should be harmonized.

The International Centre for Science and High Technology (ICS), which is an institution within the legal framework of the United Nations Industrial Development Organization (UNIDO), with headquarters in Trieste, Italy, focuses on the transfer of know-how and technology from industrialized to developing countries.

ICS-UNIDO has focused on the topic of EDPs as one major branch of its activity aiming at bringing the advantages of today's skill in the technical areas of chemistry, environment and high-tech/new materials direct to developing countries and to stimulate a diffusion of harmonic decisions to be taken on the global issue of plastic waste to the benefit of these countries. During 1997-1998, the actions undertaken by ICS in the subprogramme of Environmentally Degradable Plastics (of the area of Pure and Applied Chemistry) included training courses and workshops which have met a strong interest and resulted in many proposals of common projects, feasibility studies and net working coordinated by ICS-UNIDO.

The first event in the ICS-UNIDO Work Programmed in 1999 in the subprogramme on EDPs is the workshop on "Environmentally Degradable Polymers: Polymers and the Environment". It is organized in Doha, Qatar, due to the importance of this issue in the Gulf countries. The workshop focuses on the impact of manufacturing and consumption of polymers on the environment, with special emphasis on pursuing a strategy for EDPs utilization in developing countries.

The workshop is organized in cooperation with the Scientific and Applied Research Centre (SARC), University of Qatar, with the support of two large industrial companies, Qatar Company for Petrochemical Industries QAPCO, and Qatar Industrial Manufacturing Company -QIMC.

The concern about the environmental pollution is one among the central issues in the policy of the government of Qatar. There is great attention to this issue, and research in the field is supported by several industrial and governmental organizations. The University of Qatar and its Research Centre (SARC) are actively involved in several projects related to the environmental pollution, in addition to its collaboration with the polymer industry in several joint projects. The University was inspired by the success of the previous training courses and workshops, organized by ICS-UNIDO in other countries.

Dr. Homaid Al-Madfa
Director
Scientific and Applied Research Centre
University of Qatar

Prof. Stanislav Miertus
Area Coordinator
Pure and Applied Chemistry
ICS-UNIDO

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Gerald Scott	-	Aston University, Birmingham, U. K.
Ramani Narayan	-	Bioplastics Inc. , USA
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ICS-UNIDO INTERNATIONAL WORKSHOP
SCIENTIFIC AND APPLIED RESEARCH CENTRE
UNIVERSITY OF QATAR
DOHA, STATE OF QATAR

SUNDAY MORNING, March 21, 1999

8:30 - 9:00 **Registration**

Opening Session

9:00 - 9:20 **Inauguration**

9:20 - 9:45 **Stanislav Miertus** – ICS-UNIDO Coordinator
Goals and programs of ICS-UNIDO, Program of Environmentally Degradable Polymers.

9:45 - 10:00 **Ibrahim S. Al-Naimi** – University of Qatar
Polymer research Activity at the University of Qatar.

10:00 - 10:30 **Break**

First Session

10:30 - 11:15 **Elmo Chiellini** – University of Pisa, Italy
Environmentally Degradable Polymers and Plastics, an Overview.

11:15 - 12:00 **Ramani Narayan** – Bioplastic Inc. & Michigan State University – USA
Rationale, Drivers and Standards for Biodegradable Plastics.

12:00 - 12:15 **Break**

Second Session

12:15 - 12:50 **R. P. Singh** – National Chemical Laboratory, Pune, India
Biodegradability and Compostability of Polymeric Materials

12:50 - 13:15 **Ziad F. M. Said** – University of Qatar
Some Environmental and Chemical Aspects of Polymer Degradation and recycling.

13:15 - 16:00 **Break and Mid-Day Intermission**

Third Session

16:00 - 16:45	**Sherif H. Kandil** – Alexandria University – Egypt Thermal Degradation of Polymeric Materials.
16:45 - 17:30	**Gerald Scott** – Aston University, Birmingham – UK Photo-Biodegradable polymers in Agriculture.
17:30 - 18:00	**Break**

Fourth Session

18:00 - 18:45	**Fred Edgecombe** – Plastic Industrial Association, CPIA – Canada Integrated Solid Waste Management: a computer Model for the Assessment of Environmental and Economic performance of Solid Waste Management option.
18:45 - 19:10	**Hassan A. Al Salah** – Mu'tah University – Jordan Waste Management in Landfill Environment in Jordan

MONDAY MORNING, March 22, 1999

First Session

8:30 - 9:15	**Gerald Scott** – Aston University, Birmingham, UK Degradable Polymers in Waste Management.
9:15 - 9:45	**Lucia H. Mei & L. Peres** – University Campinas – Brazil Plastic Waste Management in Brazil and Latin American Countries.
9:45 - 10:10	**Ideisan Abu-Abdoun** - University of Sharjah – UAE Natural Weathering of Polyethylene Films: FTIR and GPC Analysis.
10:10 - 10:35	**Break**

Second Session

10:35 - 11:00	**Fred Edgecombe** – Plastic Industrial Association, CCPIA – Canada Plastic Waste Management in Canada.
11:00 - 11:25	**Gerhart Braunegg** – University of Technology, Graz – Austria Plastic Waste Management in Austria.

11:25 - 11:50 **Erhan Piskin** – Hacettepe University – Turkey
Plastic in Turkey: Production/Consumption/Waste.

11:50 - 12:05 **Break**

Third Session

12:05 - 12:30 **El-Refaie Kenawy** – University of tanta – Egypt
An Overview on Plastic Waste Management in Egypt.

12:30 - 12:55 **M. A. Baban** – Gulf Organization for Industrial Consulting – Qatar
Plastic Industry in GCC States

12:55 - 13:15 **Saeed Al-Alawi** - University of Bahrain
Plastic and Plastic Waste Management in Bahrain

13:15 - 16:00 **Break**

Fourth Session

16:00 - 16:25 **Ivan Chodak** – Slovak Academy of Science, Bratislava – Slovakia
Plastic Waste Management and the Position of EDPs in Slovakia.

16:25 - 16:50 **Zhengzhonh Shao** – Fudan University – Shanghai – China
Plastic Consumption, Plastic Waste Management and the Development of Environmentally Degradable Polymers in China.

16:50 - 17:15 **Khalid A. Abid** – University of Sanaa – Yemen
Plastic Management in Yemen.

17:15 - 17:35 **Laith A. Latif** – Qatar Petrochemical Company, QAPCO – Qatar
The impact of Polymer Stability on the Environment.

17:35 - 18:00 **Break**

Fifth Session

18:00 - 18:30 **Eskender Setoudeh** – Rubber Industries Engineering & research Centre, Tehran Iran.
State of Rubber Industry in Iran and its Environmental Impacts.

18:30 - 19:00 **El-Rafaie Kenawy** – University of Tanta – Egypt
Environmentally Degradable Polymers and Plastics, from Waste Gelatin to Agro-Industrial Applications: A case Study of ICS-UNIDO Follow-up Policy.

Tuesday Moming, March 23, 1999

First Session

8:30 - 9:15 **Ramani Narayan** – Bioplastic Inc. & Michigan State University – USA
Overview and Case Studies of Biodegradable Plastic technologies.

9:15 - 10:00 **G. Braunegg** – University of Technology, Graz – Austria
Production and use of Polyhydroxyalkanoates from Renewable and Non-renewable Resources

10:00 - 10:30 **Break**

Second Session

10:30 - 11:15 **Giovanni Floridi** – State of the Art and Future Perspective of Starch – Based Biodegradable Materials.

11:15 - 12:00 **Ivan Chodak** – Slovak Academy of Science, Bratislava – Slovakia
Improved Performance of Environmentally Friendly Materials Via Modification of Themoplastics.

12:00 - 12:15 **Break**

Third Session

12:15 - 12:45 **Khalid Al Assaf & R. Vogel** – SABIC – Saudi Arabia
The Effect of Thermal Stress on Polypropylene Properties and Phosphite Additive Degradation.

12:45 - 13:10 **Mohammad E. Kassem & M. A. Al Ali** – University of Qatar
Electric Field Induced Degradation in Modified Poly(vinyl chloride).

13:10 - 16:00 **Break**

Fourth Session

16:00 - 16:45 **Elmo Chiellini** – University of Pisa – Italy
EDP's: Hydrosoluble Polymeric Materials, Poly(vinyl alcohol).

16:45 - 17:05 **M. E. Kassem & I. S. Al-Naimi** – University of Qatar
Influence of Dopant and γ-irradiation on the Performance of Poly(vinylalcohol) Properties and Applications.

17:05 - 17:45 **Erhan Piskin** – Hacettepe University – Turkey.
From Lactic Acid to Polylactic Acid: Synthesis, Processing & Applications.

17:45 - 18:10 **Break**

Fifth Session

18:10 - 18:35 **Lucia H. Mei** – University of Campinas – Brazil
Follow-up of ICS-UNIDO Workshop Held in Brazil – November 1998.

18:35 - 19:00 **Khadher Al-Hassan** – University of Science & Technology – Jordan
Fluorescence Probes to Polymer Characteristics, Degradation and Molecular Weight Determination.

19:00 - 19:25 **Hassan Al-Salah** - Mu'tah University, Jordan
Polyurethane Elastomers and Mechanistic Aspects of PUE Degradation.

Wednesday, March 24, 1999

First Session

VISIT TO QATAR PETROCHEMICAL COMPANY – QAPCO

8:15 **Departure from Oasis Hotel**

9:30 - 9:50 **Reception at QAPCO**

9:50 - 10:10 **Eng. Abdul Aziz** – T & D Supervisor
A Brief Lecture on QAPCO Profile

10:10 - 11:15 **Hassan Al-Rashid** – LDPE Superintendent
Largest producer of Low Density Polyethelene in the Middle East.

11:15 - 13:00 Site visit to QAPCO Facilities (Two groups): LDPE Plant Application Centre-Central Lab. Ethylene Plant and Jetty Area.

13:00 - 14:30 Lunch at Sea Line restaurant, Messaieed Beach

14:30 Back to Doha

AFTERNOON FREE

Thursday Morning, March 25, 1999

First Session

8:30 - 9:00 **Fred Edgecombe** – Plastic Industrial Association, CPIA – Canada
General Overview on Recycling.

9:00 - 9:25 **Hazim Al-Kadhi & Ziad Said** – QIMC – University of Qatar
Plastic Waste and Recycling in Qatar.

9:25 - 9:50 **Reena Susan George** – University of Kuwait
Recycling of Waste Latex products and its Utilization.

9:50 - 10:15 **K. G. Al-Ali Ali Al Saigel & N. J. Bagchi** – Department of Environment, Ministry of Municipal Affairs & Agriculture
Lagislation & Logistics of Plastics & Recycle.

10:15 - 10:40 **Break**

Second Session

10:40 - 11:00 **M. I. Raouf – SARC**, University of Qatar
Misunderstanding of Fundamentals & Concepts in Plastic Degradation.

11:00 - 11:20 **Sherif H. Kandil** – Alexandria University, Egypt
Impact & Follow-up of ICS-UNIDO Training Course on Environmentally Degradable Polymers, Alexandria – Egypt 1997.

11:20 - 11:40 **Salman R. Salman** – University of Qatar
Recycling and Degradation of High Impact Polystyrene

11:40 - 12:00 **General Discussion & Evaluation of the Workshop**

12:00 - 12:20 **Closing Ceremony**

ENVIRONMENTALLY DEGRADABLE POLYMERS

GOALS AND PROGRAMS OF ICS-UNIDO, PROGRAM OF ENVIRONMENTALLY DEGRADABLE POLYMERS.

S. Miertus
International Centre for Science and High Technology
Area Science Park, Padriano, 99 Bldg. 12, Trieste 34012

Since its establishment in 1988. The International Centre for Science and Technology (ICS)- an autonomous body of United Nations Industrial Development Organization (UNIDO), has directed its efforts towards the following three scientific fields: pure and applied chemistry; earth, environmental and marine sciences and technologies applicable to the environment in the context of promoting sustainable industrial development as defined and pursued by UNIDO.
In the implementation of the ICS mandate, an important role is played by the following methods of interventions:

- Expert group meetings, seminars and workshops;
- Training courses for technologists and researchers from developing countries.
- Creation of a network of focal points and R&D Centers in the developing area;
- Fellowships;
- Publications and training packages
- Development of follow-up projects

In the Area of Pure and Applied Chemistry the following sub-programmes will be described in detail:

1. **Catalysis and sustainable Chemistry**, with the aim to improve and renew processes and products, namely catalytic processes, as the keystone for efficient conversion into more valuable and cleaner chemical output, and for pollution prevention.
2. **Environmentally degradable plastics**. Due to the characteristics of classical plastics, their use has led to the accumulation of waste, which is difficult to recycle; thus leading to an environmental problem that could be partially solved by the use of degradable plastics.
3. **Remediation:** focusing on problems of chemically contaminated soils and technologies of decontamination of soil and water.
4. **Combinatorial chemistry and combinatorial technologies**. Focusing on new techniques ad technologies applicable for search and development of new chemical compounds .

In this presentation, more detail will be given on the sub-programme on "Environmentally degradable Plastics". The ways of co-operation of ICS-UNIDO with developing countries and emerging economics and also shortly overviewed.

ENVIRONMENTALLY DEGRADABLE PLASTICS HYDROSOLUBLE BIODEGRADABLE POLYMERIC MATERIALS POLYVINYLALCOHOL.

Elmo Chiellini
Department of Chemistry & Industrial Chemistry
University of Pisa, 56126 Pisa, Italy

Environmentally degradable polymers have been receiving increasing attention for the preparation of plastic items that are supposed not to create environmental burden once they enter the stream of post-consume items. Packaging for single doses items in hygiene, agricultural and fish farming applications is becoming more and more diffused as driven for safety and ecological reasons. In this contribution an overview will be provided on hydrosoluble EDPs with particular reference to plastics based on polyvinylalcohol taken as a case study.

PVA is considered as the only true biodegradable synthetic polymer consists of a carbon backbone. Evidences of this feature have been reported since the early thirties in studies carried our with single micro-organisms and symbiotic mixed cultures. In the early seventies biochemical pathways have been designed by assuming that hydroxyl groups are enzymatically oxidized to p-diketones or a-keto groups and subsequently hydrolyzed with the ultimate fission of the carbon-carbon bond. Nevertheless due to that nowadays consolidated and future consumption of PVA consumption formulations, investigation on the post-consume items have to be performed both in liquid and solid culture, according to the several procedures aimed at closely reproducing the conditions of natural ecosystems or waste treatment facilities.

In this context a carefully extensive investigation on the biodegradability of different commercial PVA based-blown films produced by blown extrusion was undertaken by means respirometric tests carried out both in liquid and solid cultures simulating sewage sludge, composting and soil burial conditions. Effectiveness of microbial populations present in the matrices utilized as inocula, was also investigated in liquid cultures iodemetric evaluation of PVA concentrations.

Results obtained evidenced is clear yet unclear effect on biodegradable rate and extent, attributable to both the environmental conditions and microbiological populations. In particular, PVA-based films and PVA undergo a very limited mineralization extent in solid cultures (composting and soil burial) where as high rate of biodegradation were observed in liquid cultures in the presence of paper mill sewage sludge and selected PVA-degrading mixed inocula

Nevertheless in remains yet unclear if the limited biodegradation rate extent, attributable to the absence of PVA-degrading microorganisms in the utilized environmental conditions or rather to unpaired interactions with organic and inorganic components analogous to those that hinder humus and polysaccharides biodegradation in soil.

The industrial manufacturing of blown extruded films based on PVA formulation will be also thoroughly analyzed as a typical case study relevant to the production of the consumption environmentally degradable plastic items.

RATIONALE, DRIVERS AND STANDARDS FOR BIODEGRADABLE PLASTICS

Ramani Narayan
Michigan Sate University
E. Lansing, USA

New environmental regulations, social concerns, and growing environmental awareness throughout have triggered the world and the search for the new and products and processes that are compatible with the environment. Thus, a new product have to be designed and engineered from cradle top grave incorporating a holistic "life cycle thinking" approach. The impact of raw material resources used in the manufacture of the product and the ultimate fate (disposal) of the product when it enters the waste stream have to factored into the design of the product. The use of annually renewable resources and the biodegradability or recyclability of the product is becoming the important design criteria. This has opened up a new market opportunities for developing biodegradable products.

Currently, most products are designed with limited consideration of its ultimate disposability. Of particular concern are plastics used in single-use disposable packaging. Designing these materials to be biodegradable and ensuring that they end up in an appropriate disposal system is environmentally and ecologically sound. For example, by composting our biodegradable plastic and paper waste along with other "organic" compostable materials like yard, food and agricultural wastes, we can generate much needed carbon-rich compost (humic material). Compost amended soil has beneficial effects by increasing soil organic carbon, increasing water and nutrient retention, reducing chemical inputs, suppressing plant disease. Composting infrastructures, so important for the use and disposal of biodegradable plastics, are growing in the US and are in part being regulatory driven on the state level.

An industry begun implementing approaches to design environmentally benign products, questions about that practicality, efficacy and the effects of such products on the environment were raised. The U. S. Federal Trade Commission (TFC), a group of State Attorney General's State Legislatures and the U. S. Congress became very concerned about the various degradability, and environmental claims being made, especially as it related to existing waste management practices. Verification of the degradability claims environmental fate and effects of the new degradable products using acceptable well-defined testing protocols were lacking.

It was in this confused, contentious, vexing, and regulatory action climate that ASTM committee D20 on Plastic undertook the development of Standards in the area of "Degradable Plastics". ASTM's proven, century old, voluntary consensus processed involving a balanced participation of government, industry, and academy was well suited order and understanding in this new area.

ASTM has, to-date, 26 approved standards on the books. These Standards cover various photo and bio environments that plastics may be exposed to, and methods to quantify the degradability. Definitions for degradable, biodegradable, and compostible plastics were crafted by the subcommittee. The International Standards Organization (ISO), CEN (European) and DIN (German) committees have or are developing Standards for biodegradable/ compostable plastics. A successful effort has been made to ensure harmony between the evolving Standards in the various organizations.

The majority of the Standards address the composting environment, given the importance of composting as an important, ecologically sound, disposal method that generates useful soil amendment product, important for sustainability agricultural practices.

BIODEGRADABILITY AND COMPOSTABILITY OF POLYMERSRIC MATERIALS

R. P. Singh
Polymer Chemistry Division
National Chemical Laboratory
Pune, India

The treatment of compostable packaging, made from natural and synthetic materials, in controlled composting and anaerobic treatment facilities can be an important method of reducing garbage. To fulfill the official regulations as a pre-requisite requirement for a packaging and packaging waste, a system for differentiating compostable from non-compostable material is necessary. After characterization of the test material, its biodegradability is determined preferably in a laboratory aerobic controlled composting test based on the evaluation of the chain or chain-ends. The laboratory test are followed by investigation of the disintegration of the material in the composting facilities and analysis to determine the quality of the compost produced.

In the present investigation we have attempted to prepare telechelic oligomers by photo-controlled oxidative degradation of high molecular weight natural rubber, high impact polystyrene and ethylene-propylene copolymers. The transformation/chain cleavage of high mol. Wt. polymers into well defined oligomers can be considered a step in the environmetntal degradation of high impact polystyrene and ethylene-- propylene copolymers generates functional groups (i. e. hydroxyl, carbonyl, acidic, ester etc.) at random in the backbone of the polymer is reduced drastically. The generated information functional groups in the chains are also enzyme/bacteria sensitive.

SOME CHEMICAL AND ENVIRONMENTAL ASPECTS OF POLYMER DEGRADATION AND RECYCLING

Ziad M. Said
Faculty of Technology
University of Qatar
P. O. Box 2713
Doha, State of Qatar

The constant increase in global consumption of plastic accompanied by an increasing quantity of used plastics dumped with domestic and industrial wastes, raising the level of solid waste pollution due to their slow degradability. Moreover most commercial polymers contain stabilizers incorporated to protect them against photodegradation. This had raised the need to have available procedures allowing cheap polymer decomposition for the non-returnable plastics which allow reasonable time for their use before being dumped as a waste. In addition dumping makes no use of either the material value or the high energy content on plastic.

As landfill space shrinks, plastic recycling continuous to ride a wave of strong public support. In addition to its 3 main advantage in reducing the size of dumped waste, the process can be done on any scale. Recycling, however, is not always worthwhile due to the cost of the process, various technical problems related to the deterioration of some mechanical properties, and also due to toxicity of some additives which might leach during recycling making recycled plastics non-suitable for use in food packaging. However, new technologies for sorting and reprocessing plastics improved, the cost will be reduced and recycling is gaining ground, the amount of recycled plastics in the industrialized world has tripled in 5 years.

THERMAL DEGRADATION OF POLYMERIC MATERIALS

Sherif H. Kandil
Department of Materials Science
Institute of Graduate Studies and Research
Alexandria University, Egypt

Polymers are affected by heat; they may degrade by various mechanisms. Depending on the chemical structure of polymers, they may undergo primary thermal decomposition through random chain scission where small fragments are obtained, or depolymerization where monomers are yielded, or through chain stripping mechanism producing light gaseous products. Cross linking may occur where the properties of the polymer are changed.

A detailed understanding of how polymers break down on heating is important in the design of materials with improved properties for particular applications. This needs to take into account the special long chain character of polymer molecules, which provides possibilities for unique types of reaction proceeding along the chain or between adjacent monomer units in the chain. Moreover structure irregularities which often determine the initiation of the degradation process should be noted.

On the other hand, there are some useful aspects of thermal degradation as controlled thermal degradation is important in composting as well as quaternary recycling of plastics waste.

Polymer degradation could be studied applying chromotographic techniques (GC, HPLC), spectroscopic techniques (IR, NMR, MS), thermal methods (DTA, TG, DSC, EGA), as well as conventional chemical analysis. Hyphenated techniques proved to be extremely useful (TG,-MS, TA-IR) etc.

The aim of this review is to discuss the various aspects of the effects of heat on polymers. It deals with different transitions along the polymer chain, the mechanisms of polymer degradation as well as the products are discussed. The manipulation of this knowledge to control the polymer degradation routes is explained.

PHOTO-BIODEGRADABLE POLYMERS IN AGRICULTURE

Gerald Scott
Aston University, Birmingham-UK

The use of muching films to increase the productivity of soft fruits and vegetables (plasticulture) is a rapidly growing technology in warmer climates. It is particularly valuable when irrigation is an essential part of the agricultural technology and since the films form a "microclimate" over the roots of the plant, not only is the temperature of the soil raised and crop yields increased but water and fertilizer usage is reduced resulting in an increased profitability to the farmer.

The downside of this technology is that the plastic films remain on the soil sustainability undegraded after harvest and if they are ploughed into the ground they interfere with root growth in the subsequent season and crop yields are reduced. Manual removal of used mulching films is labor intensive and costly to the farmer but the development of polyolefins that degrade sharply at the time of harvest has removed this problem.. By ploughing the embrittled plastics into the ground, the cost of collection and disposal is eliminated with further increase in profitability to the farmer. No accumulation of the plastic occurs and it has even been found possible to reduce the film gauge to 10μm because there is no longer a need to manually remove it from the soil.

Photo-biodegradable polypropylene is also now used in the USA in hay bailing twines which break up and biodegrade after one year. In Japan, photo-biodegradable polypropylene is used in the encapsulation of fertilizers for controlled release. The fertilizers are delivered over periods ranging from the time of application up to 12 months, leading to a substantial reduction in the fertilizer usage and decreases pollution of water-course

PLASTIC WASTE MANAGEMENT

INTEGRATED SOLID WASTE MANAGEMENT A COMPUTER MODEL FOR THE ASSESSMENT OF THE ENVIRONMENTAL AND ECONOMIC PERFORMACE OF SOLID WASTE MANAGEMENT OPTIONS

Fred Edgecombe
Plastic industrial association
CPIA, Canada

The presentation describes a new user friendly tool designed to help municipal waste managers optimize their waste management systems from an economic and environmental impact perspective.

The model evaluates material from the time they are set out for collection to the time when recycled material, usable compost or recovered energy is available for delivery to user.

The model incorporates the best available life cycle inventory data on waste management options and enables the user to assess the environmental burdens (energy and emissions to air, water and land) of each available waste management option. These options (recycling, composting, energy recovery, and landfilling) are provided for all major components of residential wastes (paper, glass, plastics, aluminum, steel and organics).

User friendliness is achieved through the use of a visual data interface whereby the user merely provides basic information on his system to 10 interactive screens on his personal computer.

WASTE MANAGEMENT OF PLASTIC IN LANDFILL ENVIRONMENT

Hasan A. Al-Salah
Polymer Science Technology Research Lab.
Chemistry Department
Mu'tah University, Mu'tah Jordan

The management of solid waste is one of the most contentious issues affecting society today. Plastic items constitute a portion of the solid waste problem and have been criticized in Jordan and world-wide because of their environmentally inert qualities. The most likely solution to the problems created by plastic is through a combination of recycling, inceneration, and bio-photodegration Polymer Scientists, having worked for years for recycling plastic materials and production of degradable plastics. This paper aims to give an outline to the Jordan efforts in developing a new multilayer greenhouse film incorporating degraded and weathered films and recycling plastic materials. It is also an outline of the degradable plastics that are currently or are soon likely to be commercially available will be discussed.

DEGRADABLE POLYMERS IN WASTE MANAGEMENT

Gerald Scott
Aston University, Birmingham, UK

The fate of polymers when they become determines the types of material that is most suitable for each application. Personal hygiene products, babies "disposable" nappies, and water soluble polymers frequently end up in sewage systems have to biodegrade rapidly. Hydro-biodegradable polymers (e.g. polyesters and carbohydrate-based polymer) have the ideal properties for this type of application and the achievement of high degree of mineralisation in sewage is essential if this waste is to be suitably processed.

Plastic used in packaging or in farming by contrast must be able to resist the effects of the environment for a pre-determined and controllable length of time before beginning to biodegrade. The hydrocarbon polymers are most suitable for this purpose. Since they degrade initially by peroxidation, this process can be controlled by antioxidants containing transition metal ions designed to "invert" rapidly in the outdoor environment to give photo-pro-oxidants. Physical disintegration must be rapid, for example as a litter or in compost, but as in the case of much of nature's litter the rate of bio-assimilation is not critical and the primary objective should be production of agriculturally useful biomass rather than environmentally polluting greenhouse gases.

PLASTIC WASTE ISSUES IN BRAZIL AND SOME COUNTRIES IN LATIN AMERICA

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In the last few years the problem of the plastic wastes in Brazil and some countries in Latin America is receiving great attention since their production and consumption is growing fast. In despite of the fact that they represent around 10% of the total solid waste, as compared with other wastes materials, they generate a pollution that takes many years to degrade in the environment. As an alternative to reduce the amount of plastics in the urban wastes, the recycling is being one of the most viable solutions.

In recent years, some kinds of plastics have gained significant importance is waste selective collection programs in Brazil; among them are LDPE, HDPE, PP and PET. The same tendency is shown by Peru which, in the last 25 years, is recycling PVC and other thermoplastics materials that come from the industrial and normal garbage. Other countries like Chile and Venezuela are working in the same direction, but different from Brazil and Peru that have more than 300 companies devoted to recycling, they have few plants working on it. Recent research by the Brazilian Environment Ministry shows that great part of the Brazilian population is willing to cooperate with the selective collection and recycling involving the urban solid waste. Some programs developed by NGOs in South America are being recognized by the authorities are a standard model program to be adopted in others emergent countries.

As another viable alternative to keep the sustainable development in the plastic area, without causing pollution in the environment, is the utilization of the EDPs. In this way, the production of PAHs in Brazil is being a promising alternative for all Latin Americans in the near future as was demonstrated in the recent Workshop sponsored by ICS-UNIDO and some industries which was held in Campinas, Sao Paulo State – Brazil in November 1998.

NATURAL WEATHERING OF POLYETHYLENE FILMS: FTIR AND GPC ANALYSIS

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The production of plastic materials has been grown to one of the major industries in all countries, and we use plastics, in almost every aspects of our daily lives. The deterioration of plastic material by all natural meterological parameters, including heats, radiation, humidity, wind, dust etc. is essential if the useful life of a plastic product is to be sufficiently extended to meet the design requirements for long term applications.

A scientific approach to stabilization of plastics subjected to outdoor exposure ca be developed if there is a full understanding of the characterization techniques, the experimental conditions, the history of the plastic material under investigation.

One of the majr techniques used to study plastic film degradation, is Fourier transform infrared (FTIR) spectroscopy and gel permeation chromatography (GPC). Results of natural weathering of polyethylene films will be discussed.

PLASTIC WASTE MANAGEMENT IN CANADA

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The presentation provides an overview of plastics waste in Canada. It highlights both the similarities and differences of waste management practices in the various regions of the country. Brief case studies of "leading-edge" or "trend-setting" approaches provided.

In addition the paper will describe analytical and engineering tools and guides which have been developed to facilitate specially the diversion of plastics from waste stream in a cost effective manner.

PLASTIC WASTE MANAGEMENT IN AUSTRIA

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Due to the strict regulation by the Austrian Packaging ordinance (Law since 1993) and due to the fact that municipal solid waste inceneration has not been accepted as a form of energy recovery, plastic packaging waste is collected and recycled throughout this country. In 1998 not more than 90.000 tons of plastic waste may be landfilled, and in 2001 this quantity will be further reduced to 60,000 tons per year. Moreover, the share percentage of mechanical recycling is individually fixed for several packaging materials, e. g. 40% for plastics, cardboard composite drink packaging, and other composites, related to the total amount of transport and sales packaging.

All producers and importers of packed goods fillers, and packers are responsible for collection and recovery of their packaging. A system (ARA) has been set up for effective recovery, sorting and recycling of wste packaging materials and is financed by fees that have to be paid for packaging waste. Recovery is executed in seven national and two foreign plants.

In 1997 a total of 83.416 tons of plastic has been collected in Austria (37.9% of the plastic waste). 45% of this could be reused (sorted qualities), the rest (46101 tons) was used for energy recovery under strict governmental regulation and control.

Details about the system and statistical data will be presented.

PLASTICS IN TURKEY: PRODUCTION/USE/WASTE

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The first industrial scale plastic production plant was built up for the production of cellulose acetate around 1960's mainly for textile industry. In 1965, during the first five years development plan, the Turkish government founded PETKIM with a capital of 250 million TL. After six years the PETKIM's first petrochemical complex was built and started up in Izmit . Low density polyethylene was produced as the first thermoplastics in Turkey in 1970. After that both plastics (including also fibers and rubbers) production and consumption have been studied around in the following trends in the expansion of other main industries including automotiviles, textile, agriculture , food drug, cosmetics and detergents. The total possesses consumption is more than one million tons per year (plastics consumption per capita is around 17.5 kg). More than 60% of the total ids the thermoplastics (e. g. LDPE, HDPE, PP, PVS, PS, PET) consumption. PETKIM Petrochemicals Co. with two main production plants (Aliaga in Izmir and Yarmea in Kocaeli) meets only 60% of the demand in Turkey. Plastics consumption pattern indicates that about 45% of the thermoplastics is used for packaging.

Turkey is a fastly growing and socially changing country, and therefore face to almost all kinds of development activities which bring related environmental problems similar to the developing countries. The "Ministry of Environment" is responsible to intervene, to control ad to implement policies adopted for the protection and conservation of the environment. The "Solid Waste Control Regulation" was issued in 1991 which is quite comprehensive legislation and contains all the management principles related to storage, transport or disposal of any kind of solid waste. The regulation also provides some targets for waste (especially packaging) recovery. The total wastes production also provides some targets for waste). The total waste production in Turkey is about 20 million tons per year 10 kg per person can be consumed . The share of the plastics wastes is the total solid waste has been reached more than 10 percent especially in urban districts. The solid waste Act includes quota and deposits for some solid wastes including plastic packaging. The quota for recycling for plastics wastes was 30% in 1977, and recycling especially in LDPE, PVC and Pet achieved in this year was 102.1%. Although the majority of recycles used to be consisted of several small size dealers, the recycling business in the country is now operated at also \industrial scale. The rest of the plastics wastes management is only at research level at the universities and respective research institutes.

PLASTIC WASTE MANAGEMENT IN EGYPT

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The Egyptian plastic consumption is estimated to be 1.2 M tons/year, mostly imported in the form of resin. (750 K tons) as well as finished products. Plastic recycling used to be a "black" industry in an economic and environmental sense, nevertheless is a very well organized industry. Recently plastic recycling is gaining great attention in Egypt where investors who are well aware of the environmental constraints have entered the market. Moreover the Egyptian environmental Affairs Agency is issuing a set of regulations to minimize the negative industry.

This review paper deals with the plastic Egyptian situation with emphasis on plastic waste management. Other activities concerning education and research in polymer recycling are also reported.

THE PLASTIC INDUSTRY IN GCC REGION

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The plastic industry in GCC region is a multi billion dollar industry involving resin producers, plastic processors, and distributors. This industry has been growing at a rate faster than in many developing and developed regions. However, it is still a long way ahead for the GCC region to be among other world leading regions.

The industry actually started in 1956 in Saudi Arabia with a plastic processing plant base on imported resins and after almost 25 years i.e. in 1981, the resin production itself started in GCC. Now, almost all major resin production, the GCC share is hardly 2%. However, the potential is tremendous to catch up with other leading regions of the world. This can be achieve by sustaining the new expansion drive for existing resins, introduction of other resins like ABS, Polycarbonate, SAN, Nylon, PMMA and specialized grades of existing resins, and widening the range of exiting products. This all represents further development opportunities.

Today, there are about 654 plastic product processors in GCC region, with an installed capacity of about 1.8 million tons. The total investment is US$2.3 billion and employment is 47, 000 employees. The market value of total products is the order of 1.5 billion US$ annually. This includes thermoset industry which is a low volume, labor, intensive industry consisting mainly of glass fiber reinforced [products. There are about 250 plants with an investment of 574 million US$ and 13, 000 employees.

The GCC per capita consumption of thermoplastic products in 1996 reached about 38 kg. This is higher than the worlds average but less than that of the developed regions such as North America or Western Europe. Nevertheless, there is tremendous scope for its growth as per-capita consumption in 2000 is projected to be the order of 60 kg.

GCC plastic processing industry is concentrated in Saudi Arabia with nearly 72% of total production. Polyethylene and PVC are the dominant resins. Application such as construction, packaging and household are well established in the region while engineering, industrial etc. are to be further developed.

PLASTIC AND PLASTIC WASTE MANAGEMENT IN BAHRAIN

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Solid waste is tone of the major problems facing Bahrain now. The density of domestic waste was around 100 kg/m^3 in 1995. The weight of waste generated per capita is around one kilogram per day that is higher than the standard value that is between 0.5 - o.6 kilogram per day.

However, a long-term solution lies in encouraging the private sector to invest in waste recycling projects by obtaining an advanced technology for separating, recycling and disposal of waste.

The number of companies involved in recycling and particular in plastic recycling is very limited. There is only one company that really involved in recycling that used cooking oil container as a raw materials.

PLASTIC WASTE MANAGEMENT AND THE POSITION OF EDPS IN SLOVAKIA, AS AN EXAMPLE OF A MIDDLE EUROPEAN COUNTRY

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Hungary, Poland, Czech Republic and Slovakia are four Middle European former socialistic countries. Although each of these countries is developing by isown way, general problems and attitudes to dealing with them are similar. Therefore the look at the situation in Slovakia may be considered as an example for the whole Middle European region.

Slovakia is a country with rather developed and extensive chemical industry. Chemical industry is the second largest contributor to gross national product (after machine industry) of the country. Production of plastic and plastic products is an important part of it. Several plants are producing plastics, such as polyofelins, PVC, polyamide and several large as well as numerous small companies make products from plastics by extrusion of injection moulding or using other technologies.

Landfill deposition is the main way of waste disposal. Separated collection of household waste has started recently in several large cities. Recycling is the main process in the case of industrial plastics. Several small companies are producing recycled pellets mainly from polyofelins, which are sold for production of less demanding products. Certain portion of waste is incinerated and some effort has been done to build the incineration facilities suitable for hazardous waste burning.

Environmentally degradable plastics are not used in Slovakia at all. The item is discussed on legislative level and few small research teams are active in Universities and Academy of Sciences. Two original materials have been developed and patented in Slovakia. First is a polyethelene foil for agriculture based on LDPE and starch. The foil approved good properties in field test, however, it was not accepted because of higher price compared to the foil made from polyethelene without the filler. Another patent deals with a biodegradable material for packaging based on polyvinyl alcohol. In spite of good properties, this material was rejected again on economic reasons.

The research on biodegradable plastics is done mainly in Slovak Technical University (Faculty of Chemistry) on special materials for medical applications and in Slovak Academy of Sciences (Polymer Institute), where blends of polyhydroxy alkanoates are investigated intended for various applications, mainly as packages.

There are many options to replace the current used plastics by other plastics or materials. Polyethyneterphthalate (PET), poly-carbonate (PC), or photolytic and biodegradable plastics can be used instead of PVC plastics. The other replacement are the using of glass, tins, paper and cartoon materials.

Few recommendations can be considered to reduce the dissemination of plastic wastes such as:

1- To produce a new kind of strong bags together with a public campaign against solid wastes.
2- To introduce a tax or a refund system.
3- To start the collection of plastic waste.

Plastic waste materials in itself do not pose an environment risk in the sense that is chemically or biologically pollutes surface water, ground water, air or soil. However, the overall presence of plastic litter is regarded as visual pollution and nuisance. Furthermore, it does not enhance the national image of the country nor tourism.

PLASTIC CONSUMPTION, PLASTIC WASTE MANAGEMENT AND THE DEVELOPMENT OF ENVIRONMENTALLY DEGRADABLE POLYMERS IN CHINA

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The consumption of plastic in China is more than 12,000 kt/a, rapidly increased with an improvement of people's living standard during recent years. However, there is always a gap between a supply an demand in almost every stage of plastic industry in China, from the output of the consumption and the recycling or reuse. The large amount of plastic waste has brought huge pressure to environment protection in China. The Chinese government and the public have paid great attention to this problem, and made gigantic efforts for a better resolution. A series of local laws and regulations concerning the management of plastic waste have been promulgated with consideration to present conditions of China. To retrieve the waste plastic for reuse and recycling is considered to be the most practical way to reduce the environmentally degradable polymers are also encouraged prudently.

In this paper, the surveys of plastic waste and disposal policy in China are given with combination of integrated assessment on plastic cycle. The current status on plastic in reuse and recycling are also presented. The development of environmentally degradable polymers in China is discussed in some details.

PLASTIC WASTE IN YEMEN

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The problems that exist in waste disposal system are rather complicated and specific. Waste is the source of an environment pollution, but is also the source of secondary raw materials and energy.

In 1987 the Environmental Protection Council (EPC) in the Republic of Yemen was established by decree no. 7 of the chairman of the Council Ministers. One of the main subjects related to the EPC programme, is the dissemination of plastic wastes.

Visitors to the Republic of Yemen will remark the abundant and defacing presence of litter, mainly composed of plastic bags and plastic bottles. The plastic bags are used by the storekeepers to wrap the items sold to the clients or to wrap the gat. The plastic bottles are mainly empty mineral water bottles.

The dissemination into the environment is apparently caused by:-

1- a lack of suitable means (container e.g.) to collect and dispose of waste
2- a lack of awareness of the need to dispose of domestic waste in an orderly way.

I Yemen plastics are produced from imported granulates. There are five types of plastic granulates used. Low density polyethylene (LDPE), Highdensity polyethylene (HDPE), Polyvinylchloride (PVC), Polypropylene (PP) and polystyrene (PS).

Plastic companies do not generate plastic waste since all scrap and by products are recycled. Other forms of reuse of plastic materials do not take place in Yemen, except for the recycling of PVC shoes.

Plastic waste can be seen all over the country. In the major cities, collection of plastic waste is part of the municipal garbage collection system. In rural areas and secondary cities no garbage collection systems exist.

PVC mineral water bottles should not reused because of technical reasons. The presently used plastic bags in Yemen are not strong enough to be used several times.

THE IMPACT OF POLYMER STABILITY ON THE ENVIRONMENT

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Polymer Stability important issue to the producers. The polymer requires protection, processing and end use stages. Protecting the polymer properties against the influence of weathering conditions is the common problem in the hot climate region including GCC region. To stabilize the polymers during their life cycle, additives are used during the manufacturing process to protect the properties of the polymers from any deterioration. The polymers may undergo a degradation process that leads to changes in the mechanical, physical and rheological properties. Degradation of polymer occurs as a result of radical formation due to the combined effects of heat, stress catalyst. In additional, the presence of oxygen induces the production of peroxide radicals that could be transformed into hydroproxides. These radicals leads to chain scission or cross-linking processes. To interrupt this degradation process , anti-oxidants such as hindered phenols is used to deactivate the peroxide radicals while the use of secondary antioxidants such as phosphates or phosphonites to eliminate the hydroperoxide groups.

Degradation of polymers can be detected using techniques such as, DSC, TGA, FTIR and others.

Another important aspect related to polymer stability is the environment. Recovering the polymers waste is concerned issue to the environment. However the current methods used to dispose of the polymers waste including: recycling, dumping (landfilling) and incineration. The degradation of polymers has an impact on the environmental management in many ways. For example, the degraded polymer could have a considerable effect on the properties of the recycled polymer. The above mentioned aspects will be highlighted in details in this program.

CASE STUDIES AND COUNTRY REPORTS

STATE OF RUBBER INDUSTRY IN IRAN AND ITS ENVIRONMENT

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The present paper is an attempt to analyzed the state of rubber in Iran and its quantitative and qualitative developments during the past twenty years.

Due to high demands for tires and rubber articles and their useful life, measures and approaches have been taken to either retread or recycle them, would be discussed.

ENVIRONMENTALLY DEGRADABLE PLASTICS FROM WASTE GELATIN TO AGRO-INDUSTRIAL APPLICATIONS: A CASE STUDY OF ICS-UNIDO FOLLOW-UP POLICY

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Plastics have also achieve a dominant position in various materials applications, among them is agriculture and horticulture. The term "plasticulture" was coined to describe the use of plastics in greenhouses, tunnels, irrigation in protective covers for crops and mulching films.

Plastic waste may represent however a serious concern for the environment because of the recalcitrance of most of the synthetics to microbial attack . The average content of the plastic waste in MSW is comprised between the 5-10% by weight. Corresponding to 20-30% by volume. This makes polymer waste management an urgent problem, needing environmentally compatible and friendly solutions, both on short and long term bases.

It is generally recognized that there is no single, simple solution to waste management but there is a fairly broad range of options comprising other reduction of the amount of material entering the waste stream and/or dealing with its ways of disposal. The search for biodegradable alternatives to stubbornly bioresistant thermoplastics has led to the exploitation of the complementary properties of natural and synthetic polymers as blends, block copolymer, or graft copolymers.

Proteins of vegetal-animal origin are of particular interest since these biopolymers have no adverse impact on human environmental health.

OVERVIEW AND CASE STUDIES OF BIODEGRADABLE PLASTIC TECHNOLOGIES

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Biodegradable plastic technologies can be classified under three broad categories and several sub-categories:

1. Aliphatic polyester bases
   - Petrochemical feedstock
   - Agricultural feedstock
   - Microbial synthesis

2. Natural polymer based
   - Starch & starch derivatives (starch esters)
   - cellulose and cellulose esters
   - proteins, other polysaccharides & amino acids

3. Blends, alloys and graft copolymers of natural polymers and polyesters.

With a better understanding of the rationale for biodegradable plastics, and with standards in place to evaluate biodegradability, technologies are under development that meets the biodegradability/compostability criteria.

Several technologies based on aliphatic polyesters and copolyesters have emerged spearheaded by Eastman Chemical, DuPont, BASF, Mitsui Chemicals, Showa High Polymer. The following figures shows the general copolyester structure.

Aliphatic polyesters like poly(ε-caprolactone) and poly(lactic acid) are also viable biodegradable polyesters that are being marketed.

Several companies are commercializing starch based thermoplastic technologies using water or other polyhydric alcohol's. These have found applications as loose-fill packaging material and in arts & crafts and toys.

Starch esters, and thermoplastic starch-polyester blends are also being commercialized.

These technologies will be reviewed including our work in this area.

PRODUCTION AND USE OF POLYHYDROXYALKANOATES FROM RENEWABLE AND NON RENEWABLE RESOURCES

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Polyhydroxyalkanoates (PAHs), a general formula is given in figure 1, are polyesters formed by many prokaryotic microorganisms when unbalanced nutritional conditions are chosen for the producing cells (1-3). Up to more than 90% of the cell dry weight can be accounted for as polymer (4). Besides, the homopolyester poly-R-3-hydroxybutanoate, consisting of 3-Hydroxybutanoate (3HB) only, two main types of copolyesters can be formed by different organisms (5). The first type of PAHs always contains C_3 units in the polymer backbone, but the side chains can contain H-, methyl- or ethyl- groups if prepared with microorganisms (5). Like Ralstonia euthropa, or prophyl- to nonyl groups are found in the side chains if the copolyester is prepared with Pseudomonas oleovorans. In the latter case branchings (6), double bonds (7), epoxides (8), and aromic structures (9) can be introduced into the side chain. Furthermore copolyesters containing chloroalkonoates (F, Cl, Br) can be produced (10-12). In the case of P. oleovorans and other strains from the group of fluorescent pseudomonads PHA formation only occurs, when the organisms are grown either with fatty acids (butanoate to hexadecanoate) or with alkanes (hexane and dodecane).

The second type of PAH is short side chain polyester, containing hydrogen, methyl-, or ethyl groups in the side chains, and having C_3, C_4 and C_5 units in the backbone of the polymer (13,14). Carbohydrates, alcohols, and low fatty acids are typical substrates for growth and PAH formation for these microorganisms. In most cases, cosubstrates have to fed to the producing cultures as precursors for copolyester formation (14, 15). Typical precursors that have been used are propionate, valerate, or 1,4-butanediol, leading to analogues of 3HB usch as 4-, and 5-hydroxyalkanoates.

STATE OF THE ART AND FUTURE PERSPECTIVE OF STARCH-BASED BIODEGRADABLE MATERIALS

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Biodegradable polymers constitute a loosely defined family of polymers that are designed to be degraded by living organisms. They offer a possible alternative to traditional non-biodegradable polymers when recycling is unpractical or not economical.

Among the products already present on the still small market of biodegradables, starch-based materials are among the most widely diffused. In this framework the concept of thermoplastic starch and the results obtained by Novamont on the behavior of thermoplastic starch in presence of other synthetic polymers is revised. In particular the role of complexation between starch and synthetic polymer molecules is discussed.

As an example of properties achieved by starch-based materials up to now, the various classes of Master-Bi products currently available on the market are shown. Their processibility, physiso-chemical properties are described in comparison with polystyrene and how low density polyethylene. Their biodegradation behavior is also discussed.

The future market perspectives of biodegradable materials are finally presented as a function of both the legal environment and the need of establishing global energy consumption criteria, based on life cycle analysis parameters, when comparing the costs of biodegradable tot hose of traditional non-biodegradable plastics.

IMPROVED PERFORMANCE OF ENVIRONMENTALLY FRIENDLY MATERIALS VIA MODIFICATION OF THERMOPLASTICS

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Biodegradability polymers are in many cases a suitable solution for decrease of the impact of plastic waste on environment. The applications as a meterial for packagings seems to be the most appropriate. Nevertheless, the properties of most biodegradable polymers are not suitable for application as flexible foils. Various modes of modification have been used to improved the properties. Among these, an admixing of various additives, mainly plasticizers have been studied. We investigated a physical modification of polyhydroxy butyrate (PHB) by called rolling of pre-formed sheets. A significant improvement of flexibility of the foil was observed, however, the material was still quite sensitive towards ageing, i.e. the substantial increase of Young's modulus accompanied with a decrease of deformation at break values was observed after several days or weeks of storing at room temperature.

The effect is believed to be diminished if a suitable second component is added to the polyhydroxy alkanoate matrix. We investigated the effect of blending the PBH with polyvinyl alcohol (PVOH). The foils made from this blend are much more flexible compared to the original PHB. The effect of physical ageing is also much less pronounced compared to PHB without the PVOH.

The effect of cold rolling of the blends was investigated. Further improvement of properties was observed compared to unrolled blends. Therefore by an appropriate combination and additives and physical modification by cold rolling a material with interesting properties can be designed.

Besides using environmentally degradable plastics, a negative effect of plastic waste on the environment can be decreased by recycling of the plastic waste. Recycling of plastic from household waste is hindered by uneven properties of the mixture of several plastics (mainly polyethylene, polypropylene, polystyrene and PVC) of varying composition. To achieve reasonable properties of the blend, efficient compatibilizers have to be used. We investigated the process using reactive processing where the compatibilizers are formed in situ compatibilized blend of LDPE and PP in different ratios is shown as an example.

Another example of the utilizing of reactive processing in two-phase materials in LDPE filled with organic fillers. An improvement of properties was observed for LDPE filled with various amount of sawdust, recycled paper or rubber crumb produced by milling the old tires. Inexpensive materials with reasonable properties are formed by such a way.

RESEARCH PAPERS

THE EFFECT OF THERMAL-MECHANICAL STRESS ON POLYPROPYLENE PROPERTIES AND PHOSPHITE ADDITIVE DEGRADATION

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Thermal-mechanical stress, as it occurs under polymer recycling and processing has a detrimenta; effect on the properties of polypropylene . The addition of processing stabilizers can be suppress in this negative side effect on certain degree. However, data about the optimum additive combination and concentration required for a certain processing condition and a certain product are rarely available. The effect of multiple extrusions at different temperatures and with different levels of two common antioxidants (Phenolic Ciba Geigy Irganox-1010 and phosphite Irgafos-168) on key properties of polypropylene is examined. Design of experiment (DOE) technique was used as the tool of choice for obtaining the data in the study. It can be shown that for certain product requirement very narrow additive concentrations must be selected. Particularly highly stressed polypropylene, which simulates the recycling case, needs unconventional high levels of phosphite addition and relatively low phenolic levels in order to meet the standards for yellowness and melt flow within an acceptable range. The degradation of phosphite stabilizer to the respective phosphate was observed by 31P NMR technique using an internal 31P standard for quantification. 31P NMR exhibits the great advantage of direct observing the additive without prior separation from the polymer matrix. Partly oxidation of the additive during sample preparation can be completely avoided. Phosphite additive degradation after multiple axtrusion at elevated temperatures can be generally correlated to an increased melt-flow and a decrease in oxidation induction time. Yellowness was found mainly due to phenolic oxidation during stress and could be inhibited by the phosphite additive.

ELECTRIC FIELD INDUCED DEGRADATION IN MODIFIED POLYVINYLCHLORIDE

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Optical and electrical properties together with oscillating strength and mechanical behavior of polyvinyl chloride doped with lead under the influence of d. c. electric field have been measures. Various techniques of measurements were used to obtain the physical and mechanical parameters. A linear correlations was fund between the direct and indirect energy of transition and both oscillating strength land internal friction Q^{-1} for the applied field less than 10 kV/cm. The obtained energy band tail ΔE showed no significant change as result of field variations. The modulus of elasticity and the internal friction showed a minimum in the range of 0.1 to 0.5 kV/cm. The results can be discussed as depolarization and degradation effect in the modified PVC.

ENVIRONMENTALLY DEGRADABLE POLYMERS AND PLASTICS: AN OVERVIEW

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Synthetic and semisynthetic polymeric materials were originally developed for their durability and resistance to all forms of degradation including biodegradation. Special performance characteristics are achieved in items derived there from through the control and maintenance of their molecular weight and functionality during the processing and under operative conditions. The polymeric materials had been and are currently widely accepted because of their ease of processibility and amenability to provide a large variety of cost effective items that helped enhance the comfort and quality of life in the modern industrial society. However, the above quoted feature, that make the polymeric materials so convenient and useful to the human life, have contributed to create a serious plastic waste burden, sometimes unfairly oversized by media because of the visible spreading of plastic litter in the environment and the heavy contribution to landfill depletion due to the unfavorable weight to volume ratio of plastic items that is in average 1 to 3.

On the other hand the expectations in the 21^{st} century for polymeric materials demand are in favor of a 2 to 3 fold increase production as a consequence of the increase of the plastics consumption in developing countries. Indeed a one-two order of magnitude jump in the plastics consumption with respect to the present annual level of 1-10 kg pro-capita can be envisaged for those countries once the living standards of industrialized countries will be approached.

The design, production and consumption of polymeric materials for commodity and specialty plastic items have certainly to face all the constraints and regulations already in place or to be issued in the near future, dealing with the management of primary and post-consumer plastic waste. In this connection the formulation of environmentally sound degradable polymeric plastic waste. In this connection the formulation of environmentally sound degradable polymeric materials and relevant plastic items will constitute a key option among those available for the management of plastic waste.

The competition with the presently adopted technologies such as burial in landfill sites, incineration with energy recovery and mechanical or chemical recycling is expected to be strengthen, even though one may predict that all of the will coexist with an appreciable decrease of landfilling practice and the introduction of the new concept of prevention that should help to rationalize the production and management of plastic waste. The technologies based on recycling. Including also the energy recovery by incineration, will be flaked by the increasing option of environmentally degradable plastics, that should replace the conventional commodity plastics in those segments in which recycling is difficult and heavily penalized from an economical standpoint.

An overview on environmentally degradable polymers and plastics cannot therefore be treated outside of the framework of the global issue related to the waste production and relevant management. The position held by environmentally degradable plastics would be analyzed in terms of the development levels so far reached and of the future perspectives. It is worth mentioning that a major aspect that has attracted the attention of plastic manufacturers, polymer scientists, and public officers, is represented by the establishment of definitions comprising all the possible categories of environmentally degradable polymer and plastics, together with suitable standards and testing protocols. The nature and fate of the degradation products constitute another crucial point for acceptance of environmentally sound synthetic polymeric materials undergoing degradation under specific environmental conditions.

As a conclusion of the analysis carried out in the presentation, no universal standards and testing protocols can be selected so far to assess the environmental degradability of polymeric environmental conditions and relevant test protocols have to be defined implying a knowledge of adequate physical parameters and microbial straints eventually utilized in the evaluation and validation tests.

INFLUENCE OF DOPANT AND γ_ IRRADIATION ON THE PERFORMANCE OF POLYVINYL ALCOHOL (PROPERTIES AND APPLICATIONS)

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The thermogravimetric and optical absorption of pure and copper doped polyvinyle alcohol have been studied. Samples of (0. 0.5, 1, 1.5%) $CuCl_2$ doped PVA were prepared. The effect of γ-irradiation doses on the optical spectral has been measured using UV visible techniques in the wavelength range from 200-1100 nm. The samples were exposed to different integrated γ-irradiation doses from 1 to 150 M Rad. Thermogravimetric studies were carried out using Perkin Elmer thermal analysis techniques at heating rate 5 K/min. A remarkable change in both decomposition temperature (T_d) and activation energy (ΔE) were observed. In the main, while both dopant and γ-irradiation produced an improvement in the optical energy band width. The analysis of the obtained data reveals a correlation between decomposition temperature and optical band energy gap. The optical parameters show a dose dependent.

(Part 2:)

The optical absorption behavior of polymer films is based upon alcohol composite. Highly sensitive photodetectors have been fabricated using thin film of PVA doped with different concentrations of amino acid. The UV measurements in the wave length range 200-1100 nm were carried out for doped, PVA, at concentrations of (0, 1, 2, 5) wt% of L α -alanine. The obtained data clearly revealed that the optical density was depressed and shifted to wavelength as the concentration increased. The insertion and assymetric optical active aminoacid leads to demininute the direct and indirect optical energy gap transition. The property has been exploited to develop an optical sensing material. The advantage of using doped polymer blends is the combination of spectral tunability.

FROM LACTIC ACID TO POLYLACTIC ACID: SYNTHESIS/PROCESSING/APPLICATION

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Lactic acid is widely used in the food, chemical, biochemical and pharmaceutical cosmetic industries. The world consumption of lactic acid is estimated to be more than 60000 metric tons per year. Because of its asymmetric carbon atom lactic exists in three forms, L- and D-, which are two optical isomers and DL- (a racemic mixture of L- and D-). Lactic acid can be made from biomass, petroleum, coal or natural gas liquids. More than half of the total consumption is produced by fermentation in which several carbohydrate sources such as whey, barley, sugarcane, soybean, milk, corn, sulfite waste liquor and potatoes can be sued as a substrate. Lactic acid fermentation traditionally conducted on a batch mode, in which both the strong product inhibition and substrate inhibition effects can limit performance. The end product inhibition by lactic acid causes several problems in which the most important ones are lactate formation rate and its recovery from fermentation broth. In order to eliminate these inhibitions and to increase both the yield and purity of the lactic acid, several in situ purification have been included in the production lines. Liquid- liquid extraction including two phase systems, membrane separation techniques, and ion-exchange systems. Solvent extraction causes several physical, chemical and biochemical problems on the catalytic activity of the cells. The use of a two phase system based on aqueous/organic two-phase systems. Different types of membranes can be used for cell recycling: dialysis, electrodialysis microfiltration, etc. hollow fibers, tubular forms, flat sheets. Membrane systems exhibit important disadvantages such as a high maintenance and operational costs. Using ion-exchange resins involves considerably less operational and maintenance costs. Microbial lactic acid production is gaining importance because of could help In the process make fermentation from renewable resources a more economical route. However, the commercial success of microbial lactic acid production is not yet realized. The main reason is the high product recovery cost and complex nature of the biological process . For large-scale commercialization, advanced fermentation process technology needs to be developed that yields a relatively pure lactic acid solutions.

ENVIRONMENTALLY DEGRADABLE POLYMERS IN BRAZIL. FOLLOW-UP OF ICS-UNIDO WORKSHOP HELD IN BRAZIL IN NOVEMBER 1998

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The PAHs production in Brazil, a family of EDP's, was born in this decade and it seems to be promising in the near future. However, to get a final product, with all thermo-and physo-mechanical properties found in the commodities plastics, it must be deeply investigated. In this sense, the Workshop on Environmentally Degradable and Recyclable polymers sponsored by ICS-UNIDO held in Brazil in 1998, put together many of the specialists in this area in order to discuss and show the viable alternatives that may be adopted to reach this goal. As the result of Workshop follow-up, some Research Institutions and Companies in Brazil, including COPERSUCAR, are convinced that the EDP's may occupy a very important niche in the plastic market and its utilization cannot be postponed. They believe that the development of projects involving advanced research groups of countries, that are interested in the same issue, is a good alternative to gain time, experience and keep in touch with the specialists on EDPs throughout the world.

FLUORESCENCE PROBES FOR POLYMER CHARACTERISTICS, DEGRADATION AND MOLECULAR WEIGHT DETERMINATION

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Demands on developing polymers implies on researches to use various techniques to understand their properties not only on macro- but on micro levels. Fluorescence spectroscopy techniques (steady state fluorescence, fluorescence lifetimes, time-resolved fluorescence, red-edge effect, etc.) is a line in this direction. In this context we have used various fluorescence probes (1-6), Figure, to study polymers (polyvinylalcohols, polyalkymethacrylate, etc...) heterogeneity: (probes 1, 2 and 3); polymers micropolatiry and microviscosity (probes 4-9). Lately we have suggested the use of twisted intramolecular charge transfer (TICT) fluorescence, occurring in probes 6-9 and elated compounds, as molecular weight detectors of polyalkylmethacrylate polymers. We are in the process of generalizing the idea to include polymers using various fluorescence probes. The fluorescence properties of PRODAN # 10 (7) and dewar- anthrancene # 11 (8) are under study and are promising in investigating polymer dynamics.

POLYURETHANE ELASTOMERS AMD MECHANISTIC ASPECTS OF POLYURETHANE BIODEGRADATION

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The chemistry and technology of several kinds of poyurethanes which are classified into the following major types-flexible foams rigid foams, elastomers fibres, and moulding compositions, surface coatings and adhesives. These various types of materials be presented. Polyester-based polyurethanes are particularly susceptible to biodegradation by a wide range of micro-organisms. The biodegradation mechanism of polyester-based polyurethanes will be discussed.

LARGEST PRODUCER OF POLYETHYLENE (LDPE) IN THE MIDDLE EAST

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Qatar petrochemical Company Limited (QAPCO) is the largest producer of Low Density Polyethylene (LDPE) in the Middle East. QAPCO is a joint multinational venture company established in 1974. It is one of the companies located in the Messaieed area along with its neighbors producing Fertilizers, Steel and Liquified Natural Gas. QAPCO is located nearest to the seaport for exporting its entire range of products to overseas and neighboring countries.

Over the years, QAPCO has established its position, as one of the market leaders for its quality product sold worldwide. It is committed tot he quality since its production started in 1981. In order to enhance its product quality, it has adopted ISO 9002 Quality Management System. It has been affirmed with ISO 9002 Certification from 4th November 1998.

Ethylene, the raw material produced in QAPCO, is the feedstock for the production of LDPE. The LDPE consumes 60% of the Ethylene produced the rest is exported to other countries. Sulphur is one of the byproducts, which is exported to other countries.

The main reason for its success us due to its strategic global location, abundant availability of feedstock (natural gas), various incentives offered by the State of Qatar, experience and knowledge of the workforce from Qatar and other countries, co-operation and other management assistance from its shareholders, political stability, etc.

QAPCO is committed to the ambitious industrialization and State of Qatar. Since its inception, it has continued to grow in all directions and hence, helping in the growth of Qatar. It expanded its production to double during 1996. Today it is participating in the projects promoted by government as well as in private sectors.

With the rapid industrialization of Qatar, QAPCO regards the protection of the environment as a fundamental principle of its business philosophy and always been constantly monitoring its emission and waste disposal. In order to strengthen its environment policy, QAPCO has started to prepare itself to adopt ISO 14001 Environment Management System in the near future.

RECYCLING

THE RECYCLING PLASTICS: A GENERAL OVERVIEW

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The recycling of plastic is reviewed under the heading of Mechanical, Chemical and Thermal Recycling. Each process is described in terms of the preparation of feedstock and the products produced. Comments are made on the political acceptance and economic limitations of the various methods of recycling.

PLASTIC WASTE AND RECYCLING IN QATAR PLASTIC FACTORIES

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The consumption of plastics, per capita, in Qatar was about 38 kg in 1996 and expected to reach 60 kg by the year 2000 which is comparable to some developed European countries. Plastic waste constitutes about 12% by weight of the total municipality solid waste which is approximately twice the world average, whereas the per capita solid waste is 1.3 kg/day, slightly less than USA but higher than many European countries. However, only about 2% of town plastic waste is recycled and the rest mostly dumped in sanitary landfills.

There are about 12 Plastic factories in Qatar with a total production of about 14,000 metric tons producing various commodity plastic articles. Some of these factories use plastic waste as an important source of their raw materials but the main recycled waste (95%) is the industrial waste from the factories who usually recycle their own wastes or sell them to other factories. However, some factories have recently established recycling units for the recycling of town plastic waste which is collected by individual rig pickers. Most of these wastes are processed into trash bags or converted to resins which are mixed with prime resins for manufacture of some low grade articles, or sold to some factories in the region or exported.

The main problem facing the recycling industry is the sorting and washing of the collected waste. Sorting is mostly mechanical (by hand) and depends on the experience of the workers. The government concern about the environment, and the activity of some environmental groups have raised the perception and created a gaining ground for recycling of solid waste. This has encouraged plastic manufacturers to increase the level and upgrade the available technology to further increasing the capacity of their factories to accommodate more town waste.

RECYCLING OF LATEX PRODUCTS AND ITS UTILIZATION

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Due to the unstable nature of the latex compound and the strict specifications in the quality of latex products such as examination and surgical gloves, the rejection in the latex industry comes to as high as 10 to 15 percent of the rubber consumed. These rejects have created a major disposal for the rubber industry. In addition the used examination and surgical gloves from the laboratories and hospitals are of sizeable quantity which requires a systematic disposal arrangement without causing a major environmental problem. Moreover the local authority prohibits the open burning of burial of these rejects due to environmental pollution. But it represent a source high quality rubber for reclamation and reuse. One of the utilizations of this latex reclaim was undertaken by developing polymer alloys with thermoplastics. Thermoplastic elastomers of isotactic polypropylene and latex recclimed were prepared using Brabender Plasticorder Torque Rheometer. The mecahnical properties of these blends are comparable with those of the conventional thermoplastic elastomers based on natural rubber and polypropylene. The effect of dynamic crosslinking of these blends has shown that it increases the mechanical properties like tensile strength, modulus of elongation, elongation at break and impact strength. Viscosities of the dynamically vulcanized thermoplastic elastomers showed that they have good processing stability and are processable as thermoplastics.

MISUNDERSTANDING OF FUNDAMENTALS AND CONCEPTS IN PLASTIC DEGRADATION

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In consistent with the importance of implementing best utilization of human resources toward maintaining suitable healthy environment for our next generations, concepts and fundamentals upon which most researches on degradation of plastics as a solution of solid waste reduction will be discussed. Proper understanding of plastic figures would better utilize human efforts toward useful tasks in control solid waste. Unfortunately, when the plastic is made more degradable it will be less recyclable, furthermore care and precautions are increasingly needed in case of toxic results after degradation.

IMPACT AND FOLLOW UP OF THE TRAINING COURSE "ENVIRONMENTALLY DEGRADABLE PLASTICS"

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A training course on "Environmentally Degradable Plastics" took place in Egypt June - July 1997. The course was organized under the auspices of ICS-UNIDO in collaboration with the Arab Society of Material Science.

The course aimed at introducing the modern concepts of environmentally degradable plastics along with offering practical training on the relevant techniques and testing procedures. A technology management mini-symposium, which included case studies on rubber recycling industry, was augmented to the course.

The course which was attended by 20 participants representing academia, industry and government institutions within the region, added a new package of technical material which is planned to be sued for teaching purposes at Alexandria University. The course material is now prepared as a book to be published to disseminate the knowledge for wider recipients. Research ideas were formulated into proposals dealing with polymer-base starch modification and recycling of pharmaceutical soft gels to environmentally degradable polymers and were submitted to UNIDO for a support. Also Ph. D. thesis protocols have evolved out of the open-ended questions which were raised in this course.

Industry interaction with academia has reflected into the request of companies asking for consultation on issues related to waste recycling. The international interaction of indigenous capacity building manifested itself into offering of a number of post-doctoral and Ph. D. grants to participants through ICS-UNIDO. Also general lectures and international conferences are scheduled to be held in the region by the Arab Society of Materials Science to further spread the concept.

RECYCLING AND DEGRADATION OF HIGH IMPACT POLYSTERENE

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The term polymer degradation is used to denote changes in the physical and mechanical properties caused by chemical relations, or changes involving bond scission in the backbone of the macromolecule.
The types of degradation processes are:
1. Thermal degradation
2. Photochemical degradation
3. Mechanical Degradation
4. Biodegradation
5. High Energy Degradation
6. Chemical degradation

Recycling and degradation are two closely related subjects:
The aim of this work:
1. Study thermal degradation of virgin and recycled Hips.
2. Study photochemical degradation of recycled Hips

Six samples of High Impact polysterene were studied. The first sample was virgin and the rest are recycled 1-5 times.Thermal aging for the samples at 100C was followed by a series of measurement. Those measurements includes optical methods. Absorbance, Reflectance and Transmittence), DTA (Differential Thermal Analysis) and Dielectric Properties. Those studies showed that the rate of degradation increases with the increasing number of recycling. The absorbance of the Hips samples increases rapidly while the transmittence decreased. DTA showed that the decomposition temperature of the polymer decreases as the number of recycling increases. The dielectic properties change drastically with the increased number in recycling.

The photochemical degradation of a new set of Hips samples was studied using Xenon lamp. It was shown that the rate of degradation under photochemical conditions is much higher than the thermo-oxidation degradation. It was found in another study that there is relationship between degradation rate and the sterioregularity of the polymer.

Recent examples will be given on the mechanism of photochemical degradation of polystyrene. Using FTIOR measurements.

اليوبيل الفضي

جامعة قطر

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