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CONSOLIDATION OF CAPACITY OF INSTITUTE OF FOOD TECHNOLOGY THROUGH CREATION OF A NATIONAL FOOD PACKAGING CENTRE

DP/BRA/82/030

BRAZIL

Technical report: Flexible packaging materials*

Prepared for the Government of Brazil

by the United Nations Industrial Development Organization,

acting as executing agency for the United Nations Development Programme

Based on the work of Mr. Joseph Miltz,
expert in laboratory analysis of food
packaging, flexible packaging materials

United Nations Industrial Development Organization

Vienna

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ABSTRACT

This report summarized the activity of the present expert during the period of January 1986 in the Food Packaging Centre (CETEA) of ITAL, Campinas, SP, Brazil.

An internal 8 three hourly meetings course was presented to the technical personnel of CETEA. In this course the structure--property-applications relationships of plastic flexible materials, and the subjects of permeability, migration, mechanical, thermal and flow properties of polymeric materials were covered. The projects being carried out were discussed and recommendations about areas of future activities, required equipment and books were made. A special support and recommendation to extend CETEA's activity to the area of transport was expressed.

1. INTRODUCTION

1.1. General

The present report summarizes the work performed in the Food Packaging Centre (CETEA) of ITAL - Instituto de Tecnologia de Alimentos, Campinas, SP, Brasil during the month of January, 1986.

1.2. Background

The Food Packaging Centre (CETEA) where the present mission was carried out, is a part of ITAL - Instituto de Tecnologia de Alimentos located in Campinas in the State of São Paulo, Brazil.

ITAL was established in 1963 and as part of it, a small packaging section was formed. This section was aided during the years by several National and International agencies including UNIDO. A rapid expansion in the activities and personnel of this group started with the present UNIDO Project (BRA/82/030) and the formation of the Food Packaging Centre (CETEA) in 1982. The project for the creation of this Centre was sponsored by the Government of the State of São Paulo, the Federal Brazilian Government and by the United Nations Development Program (UNDP) through the above mentioned United Nations Industrial Development Organization (UNIDO) project.

There is an intention to turn CETEA into a National Centre for Food Packaging that will support the rapidly growing Food Industry in Brazil and to a National and International (for Latin America) Training Centre in the important field of Food Packaging. Moreover, there is an intention at CETEA to expand also into the very important field of Transport. In the opinion of the present expert this will be a very constructive expansion as such a move will enable to examine and analyze the package and the system as a whole. The package is only one part in the distribution system and in order to analyze this system the transport aspect should be evaluated as well. This subject will be dealt with however later in this report.

At present, CETEA is divided into four groups:

a) Plastics and paper

b) Metals and glass

c) Packaging Systems and New Packaging Technologies

d) Analytical Evaluations

The total number of employees in this group is 30. Among these are 4 graduates with a M.Sc. degree, 10 graduates with a B.Sc. degree, 11 technicians, 1 secretary and 4 services persons.

The vast majority of the graduate technical personnel is young, inteligent and devoted to their job. However, most of them are graduates in Food Engineering and related areas (11) and have little experience in some aspects of plastic and plastic packaging although their desire to learn and to acquire knoledge can be very easily noticed.

The fact that 4 out of 14 graduates have a maters degree and 6 additional are now studying towards and advanced (M.Sc.) degree, reinforces the previous statement. This is a very constructive attitude of ITAL's and CETEA's management that in the long range will certainly pay off, in the authors opinion.

The UNIDO/Brazil Food Packaging Center Project (BRA/82/ /030) was initiated in 1982 and was scheduled for five years, namely it is planned to finish in 1987.

1.3. Objectives of the mission

To advise and establish a better understanding on structure- -property-applications relationships in flexible packaging in general and in particular:

1. To present a short course related to the influence of structure and processing parameters on the properties of polymers in general and polyethylene in particular; to discuss the effect of the environment on polymer behaviour and performance.

2. To discuss the effect of the environment on the properties of paper and paperboard.

3. To discuss the theoretical and practical aspects of permeability through and migration from plastic packaging materials.

4. To assist the Centre in the evaluation of the testing methods and techniques now in use for research and quality control tests of polymers, paper and paperboard.

5. To advise on complementary equipment required for the characterization and evaluation of polymers, paper and paperboard.

6. To evaluate the main projects being executed in the area of polymeric packaging and to orient the program for future projects.

7. Visit the food processing and packaging industries to detect the main problems in these areas.

8. To assist the local industries with the personnel of the Centre in solving their problems.

9. To prepare a final report summarizing the activities during the mission.

2. DESCRIPTION OF WORK PERFORMED

2.1. General

As was pointed in section 1.2. the technical personnel of CETEA were insufficiently familiar with some important aspects of plastics and plastic packaging.

Another UNIDO expert, Dr. B. Czerniawski gave a course on the methods for manufacturing of flexible packages and provided valuable data on different properties of plastic packaging materials.

It was felt however by the present expert and by the UNIDO project manager that most of the technical personnel do not have enough knowledge on structure-property-application relationships and this personnel indicated a great interest in expanding their knoledge.

2.2. Internal Short Course

Originally six 3 hourly lectures were scheduled to be given in the internal short course. With the course progress it was felt however, by the consultant, that these six meetings will not enable to cover some of the most important topics. Therefore, in coordination with UNIDO's project manager and with the full agreement of the technical personnel, two additional meeting were added. As there is no way in which all the important topics on polymers and plastic packages could be covered in a one month mission, a list of priorities was prepared in coordination with UNIDO's project manager. The topics covered are:

a) Chemical structure and structure-properties relatio--ship of the most the widely used addition and condensation polymers. Printed material on this subject was given to the course coordinator and is also given in Annex I.

b) Molecular structure, namely, molecular weight averages and molecular weight .stribution, the methods of their determination, and their effect on tne different properties.

c) General ideas on flow properties of polymeric melts.

d) Mechanical properties of polymers and the effect of structure on these properties.

e) Some thermal properties (primarily glass transiton and melting temperatures).

f) Transport through (permeation) and from (migration) plastic packaging materials, theoretical and practical aspects.

g) Properties of paper and paperboard:

There was insufficient time to talk about this subject with the whole group and therefore the main properties and test methods were discussed with the personnel involved in paper and board evaluation.

h) Transportation and distribution:

Because of lack of time, this subject was discussed several times only with the people from the Packaging Systems group and with UNIDO's project manager.

The list of participants in the short course is given in Annex II.

A review of the available books at ITAL and those that were ordered revealed that some basic books dealing with structure--property relationship of polymers and flexible packaging materials are missing. A list of recommended books to be aquired is given in Annex III.

2.3. Visits

Because of the short duration of the mission, only two visits to industry were originally scheduled. However, due to difficulties in arranging these visit at convenient times and as a result of UNIDO's project manager opinion that it will be more beneficial to the group if additional lectures are given instead of visits, the visit to "Polipel Embalagens Ltd." and "Poliolefinas" were cancelled.

Thus, no visit to industry were made.

However, one of the graduates at CETEA is working on her Masters Degree on a project on "Laboratory simulation of tomatos damage during transportation" and as the author of the present report works also in the field of Transport Packages and is experienced in this area, it was suggested that he helps in directing the Laboratory and field tests.

In order to find the available and most suitable equipment to carry out the laboratory tests, visits to the Department of Mechanical Engineering at UNICAMP University, Campinas and to the Institute for Technological Research (IPT) in São Paulo were made. It was then decided that the laboratory tests will be carried out in IPT (inspite of the longer distance) because of its better suitability and grater availability.

2.4. Projects Discussed and Evaluated

2.4.1. High Density Polyethylene (HDPE) for Vegetable Oil Packaging

CETEA is carrying out a research project for a company by the name of "EMBRAPA" to study the possibility of using HDPE for vegetable oil packaging. This project was discussed with the people involved in it. The methods of analysis of the oil and package were outlined and the advantages and disadvantages of this package were pointed out. This project is supported by the Federal Government of Brazil.

2.4.2. Off Flavors from Residual Solvents

In CETEA a project was carried out for "FINEP", sponsored by the Federal Government on residual solvents in flexible packaging materials. This is a very important project as different packaging and food companies struggle with the problem of off flavors in foods steming from residual solvents in the packaging material. This is also the case with "ALMO" a polypropylene film manufacturer and with "ÁGUIA CENTRAL" - a food manufacturer - as well as with many other companies. The problem was discussed in detail. The sources .or the off flavors were explained and the methods and conditions for analysis outlined in detail.

2.4.3. HDPE bottles for milk packaging

A Blow Molder by the name of "ELETROFLEX" and a food processor working in sterilization expressed their interest in using HDPE bottles in order to package sterillized milk. This is supposed to be a multi-use package primarily for poor people.

The limitations of such a package during sterillization and for a muliple use and the problems involved in shipping, cleaning, etc. for reuse were outlined. This, inspite of the relatively low price of this package if it could really be reused without hazards.

2.4.4. Polypropylene cups for tomato pastes

A company by the name "POLIBRASIL" has asked CETEA to evaluate the possibility of using polypropylene cups for tomato paste packaging. The subject was discussed in detail and the expected short shelf life of the product was pointed out as browning is expected to occur due to the high oxygen permeability of polypropylene.

2.4.5. Static and Dynamic coefficient of friction of papers

"Pan-Brasil" has submitted papers and papers coated with polyethylene and Ethylene Vinyl Acetate (EVA) for the evaluation of the coefficient of friction. The methods used for coefficient of friction determination were discussed. After some suggestions for improvements in the methods of testing, actual tests were carried out in the laboratory using an attachment supplied by "Instron" and an instrument supplied by "TNO" available in CETEA. The results obtained by the two methods were compared.

2.4.6. Migration of Styrene from Polystyrene Packages

The National Foundation for Research and Development -"CNPq" - of Brazil is sponsoring a project at CETEA on migration of styrene from polystyrene (PS) packages.

The methods and conditions for analysis of residual styrene in PS were discussed in detail with the project manager and methods for studying migration and data analysis were outlined. Relevant literature, including a theoretical approach for data interpretation from the work of the present expert was supplied.

2.4.7. Paper sacks for transport of goods

"FAE" - The Brazilian Foundation for Students Assistance has asked CETEA to evaluate the performance of mutiwall paper sacks for the overpackaging of consumer packaged foods like rice, sugar, beans, etc. This project is sponsored by the Federal Government. The methods for the evaluation of the performance of paper sacks were discussed with the relevant personnel and UNIDO's project manager.

2.4.8. Laboratory simulation of Tomatoe damage during transportation

As was pointed out in section 2.3, one of the graduates at CETEA works for her M.Sc. degree on the above mentioned project. Although this is an internal project, the subject of tomatoes damage during the transportation is very important in Brazil as very big quantities are damaged during handling and transportation.

The author of this report participated in a field trip in which the tomatoes were presorted in a farm in Ibiuna according to the advice of the expert and then shipped by truck in two kinds of boxes (wooden boxes-very common in Brazil - and corrugated boxes) to the Central Fresh Produce Distribution Place (CEAGESP) in São Paulo - a distance of 71 kilometers. The tomatoes were analyzed again for the occured damage (in the presence of the expert) in CEAGESP.

As was pointed out in section 2.3 after visits to IPT and UNICAMP, IPT was chosen as the laboratory for simulation testing of damage during transportation. An additional trip was carried out to IPT in São Paulo where vibration tests were carried out with wooden and corrugated boxes filled with tomatoes according to the advice of the expert. The tomatoes were analyzed after the tests and the testing conditions to simulate transportation were chosen.

2.4.9. A Laboratory for transport analysis

In section 1.2 it was pointed out that there is an intention in ITAL that CETEA expands its activities into transport packaging and simulation. Until several years ago IPT in São Paulo used to work in transport packaging and there was no justification for an additional such laboratory in the State of São Paulo. However in the last 2 - 3 years the activity of IPT in this field is diminishing steadily. Several engineers working in this area left IPT and only a very small group of 3 people (1 engineer and two technicians) remained. It is anticipated by CETEA's personnel that the activity of this group in the field of transport packaging will further decrease and that the effort there will probably be devoted to the area of railroad analysis. If this happens, Brazil will be left without any center working in the field of transport packaging and simulation. This is the main reason why CETEA is interested in expanding its activity to the field of transport. The present expert strongly supports this idea. Today experts in Packaging look at and regard this field as a system in which the package itself is only one part. The distribution environment is a very important parameter in determining the performance of the package and thus the shelf life of the product. Expanding CETEA's activity to include transport will add a new dimension to its activity. This will enable CETEA's personnel to evaluate the performance of the package in the whole distribution systems. The first stage will naturely include food and agricultural products packaging but it can later on expand to the whole area of packaging.

This subject was discussed in depth with UNIDO's project manager and the personnel from the Packaging Systems group. The necessary equipment (according to priorities) and the required floor space were outlined.

2.4.10. The use of computers in packaging and food analysis, processing and design

This subject was brought up by the technical personnel of CETEA. This is a subject with an increasing importance and since the present expert uses computers in his Packaging Laboratory, they wanted to learn about the possible applications and advantages of computers. A discussion was held in which the expert explained the different aspects of data acquisition, analysis and storage by a computer and the different functions and roles a computer can play in a modern Packaging Laboratory.

2.5. Seminar to Industry

A one full day seminar was given to industry to cover the area of Package-Product interactions and Innovations in Plastic Packaging.

40 persons from the Food, Packaging and Plastics industries participated in this seminar in addition to approximately 15 persons from ITAL.

The topics covered in the seminar are given in Annex IV.

3. RECOMMENDATIONS FOR FUTURE ACTIVITIES

3.1. Training

The attitude of ITAL's and CETEA's management which enables university graduates to continue their studies towards M.Sc. degrees is very constructive in the authors opinion. It is important however that some of these people continue their studies abroad towards a Ph.D. degree and become group leaders in research and development.

Short period training programs should also be continued to allow the professional personnel to gain knowledge and experience.

3.2. Research and development projects

Inspite of the young age and limited experience of most of the professional personnel in research and development in plastic packaging in general and in flexible packaging in particular, it is the experts opinion that this personnel is ready to carry out such projects. They also posses most of the equipment required for this purpose. The areas to be covered or expanded are:

3.2.1. Off flavors from plastc packages and laminates

It is the justified policy of Brazil to increase, as much as possible, the local production of polymers and packages and to decrease its dependence on imports.

The group working with plastics is familiar with many methods of analysis. They should however familiarize themselves also with some additional methods as well as with all flexible packaging materials manufacturers and with their products.

By doing so, this group can become a leader in this field and play a major role in reducing the levels of residual solvents from plastic packages. This will eliminate off flavors in the packaged products.

3.2.2. Migration

The area of migration of monomers and low molecular compounds from plastic packages should be extended to cover, gradually, the major problem causing plastics.

3.2.3. Aseptic Packaging

Aseptic packaging of citrus and tomato juices and of other liquid and semiliquid products has been increasing rapidly in recent years in the Western world. To the authors best knowledge this kind of packaging is very limited in Brazil. As Brazil is a major citrus juice manufacturer, this type of packaging will inevitably, sooner or later, expand in this country too. The Plastic and Paper and the Packaging Systems groups should familiarize themselves with this kind of packaging (its advantages and disadvantages) and start doing research in this field so it will be able to help the local industry in due time.

3.2.4. Modified and Controlled Atmosphere Packaging

The loses in fruits and vegetables in Brazil are huge due to improper packaging, handling and transportation.

Modified and Controlled Atmosphere Packaging can significantly increase shelf life and reduce these loses (the subject of handling and transportation will be dealtn with later).

The Plastics and Paper and the Packaging Systems groups should familiarize themselves with this kind of packaging and initiate projects with the most problematic products.

3.2.5. Paper and Paperboard Packaging

This area did not receive enough attention until now. Because of the short time of this mission, the expert held only limited discussions with the group working in this field. The people are not familiar enough in the structure-property relationship of paper and paperboard and the methods of their testing and evaluation and need training in this field.

3.2.6. Retortable Pouch and Bag in the Box

CETEA has carried cut studies with the Retortable Pouch (sometimes also erronously called Retort Pouch). Most of the activity in this area was significantly reduced because of the lack of locally made appropriate laminates. It is the opinion of the author that work in this area should continue, including the development of new products to be packaged in the retortable pouch.

Much of the work today in this area in CETEA is devoted to the institutional size retortable pouch. This fits the opinion of this author that the prospects of success are much bigger in the large pouches.

3.2.7. Laminates and Barrier Materials

There are many developments in the area of laminates and new barrier materials, "plastic cans", composite cans, etc., part of which were covered by the expert during the "Seminar to Industry".

Again the Plastics and Paper and the Packaging Systems groups should familiarize themselves with the advantages and limitations of these packages. The sterilizable "plastics can", will inavitably replace in the future some of the metal cans and it will be to the benefit of CETEA if processing and shelf life studies of some selected foods in these packages (initially-imported) are carried out in the near future.

3.2.8. The use of a computer

The use of a computer in data acquisition analysis and storage is penetrating rapidly into all advanced packaging laboratories.

It is highly recommended that some people of CETEA learn this subject in depth and enable the introduction of a computer (personal) to the Packaging Center.

3.2.9. Transport

It was mentioned several times in the present report that it is the intention of CETEA to expand its activities also into the field of Transport and that the present expert supports this idea.

It was also mentioned that loses in fruit and vegetables due to improper packaging,handling and transportation are great. It is recommended that the Packaging Systems studies the subject of Transport in depth and after acquisition of the appropriate equipment, extends the work now being carried out with tomatoes to other fruits and vegetables. Moreover, the behavior and performance of all the new packages (like the retortable pouch, aseptic laminated carton packs, high barrier pouches, "plastic cans" and composite cans) will have to be evaluated during transportation also.

3.2.10. Inverse Gas Chromatography

Inverse Gas Chromatography (IGC) has been shown by several researchers, including the present expert, to be a very powerful tool to study interaction between polymers and different gases, vapors and liquids. This method can also be applied for glass transition, melting temperatures as well as difussion coeficients determination. The method was outlined and discussed with one of the graduates (Ms. Marisa Padula) and it is recommended to be introduced to CETEA.

3.3. Recommended Equipment

A list of recommended equipment to be acquired is given in Annex V.

Structure, Properties and Applications of Polymers used as Packaging Materials

Dr. Joseph Miltz

Department of Food Engineering and the Packaging Laboratory

Technion - Israel Institute of Technology, Haifa, Israel

INTRODUCTION

Packaging materials have been in use for many centuries. Even in ancient times wood, leather, glass and ceramics were used for holding foods and beverages.

In the past packaging used to be an art, but the rapid development of food technology and preservation in the present century, accelerated by the advent of new packaging materials (of which polymers are the leading group), added a new dimension and turned it into a science. At present, extensive effort and means are being continuously invested, and numerous research programs carried out, in the search for improved quality and reduced cost. The fields of interest are metals (aluminium and steel), with the subsidiary areas of tin-and plastic coatings, and as just noted- polymers, which are the subject of this chapter, as well as laminates (combinations of metals, paper and polymers).

The hazards of off-flavor and/or off-taste, toxicity, and carcinogenicity, associated with migration of certain low-molecular weight compounds from the package to its contents, underline the importance of the analytical aspect of packaging materials, which is in turn associated with that of structure.

In this chapter the structure, properties and applications of the most important polymers used as packaging materials are briefly described. The aquaintance with the composition and structure will assist the reader in the analysis and characterization of these polymers.

Organic polymers, or plastics, are compounds of high molecular weight consisting of many repeating units of low and uniform molecular weight, so-called " mers" or " monomers". The monomers are usually gases or liquids at room temperature and pressure. The polymers, usually solid under those conditions, differ from their " building blocks" in that they have a distributed molecular weight (which, together with its high value, is responsible for their unique properties) rather than a uniforn one. The average molecular weight of a polymer range from 10^3 to 10^7; for the most common, commercial compounds the interval is 5×10^3 to 5×10^5.

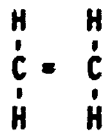
Polymers can be classified into natural ones like rubber, starch, proteins, etc., and synthetic or man-made ones. The latter in turn fall into two categories, according to the type of monomer and polymerization reaction: addition polymers and condensation polymers.

Addition Polymers

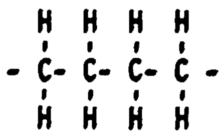
Addition polymers are obtained through a reaction whereby one monomeric unit is added to another without any by-product; the vinyl or diene compounds are typical of this category.

Polyethylene

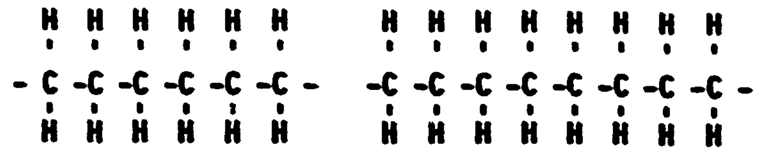
The simplest of all monomers, as far as chemical structure is concerned, is ethylene:



Through a chemical reaction, the double bond can be opened and two ethylene molecules combined into a dimer:



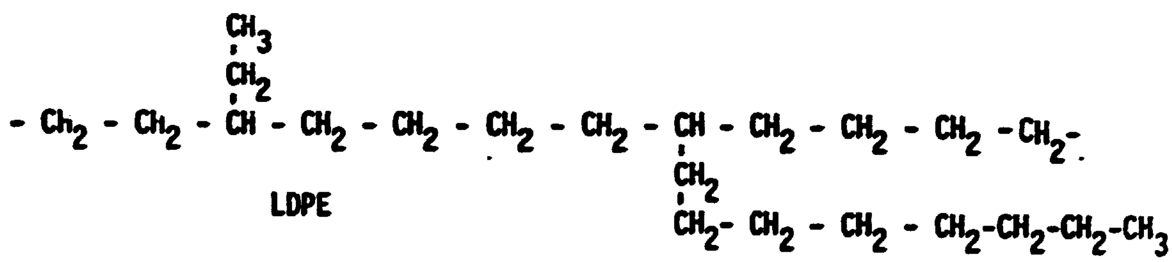
Further additions yield a trimer and tetramer respectively:



Trimer Tetramer

Finally, upon the addition of many repeating units the polymer- polyethylene (PE) is obtained.

There are two variants of the polymer, differing in structure and properties as well as in the manufacturing process, and characterized as " low-density" and " high-density" polyethylene respectively- LDPE and HDPE for short, the first being a " branched" and the second a " linear" compound.



LDPE

$$- CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 -$$

HDPE

As can be seen, the " branched" compound is characterized by side branches of ethylene units attached to the main (or " backbone") chain and terminating mostly in a methyl group or occasionally in a double bond. A side branch of six carbons or less is conventionally defined as " short" and one of more than six- as " long" (1). The actual length of a long branch may in principle approach that of the backbone. It is obvious that the branched compound contains a larger proportion of methyl groups than the linear one- 20 to 40 against only a few, per 1000 carbon atoms; by contrast, the linear compound contains a larger proportion of double bonds - 2.5-3.0 against 0.3 per 1000 carbon atoms. Both facts can be taken advantage of in infra red (IR) analysis .

LDPE, one of the cheapest of all polymers, is manufactured by the so-called " high-pressure" process. Its degree of crystallinity is in the range of 40-60% and the melting range of the crystallites is 105-115°C: the density of most LDPE grades is in the range of 0.910-0.927 gr/cc. The degree of crystallinity and the density (or specific volume) of polyethylene are related in the form:

$$\theta = \frac{V_a - V}{V_a - V_c} = \frac{1/\rho_a - 1/\rho}{1/\rho_a - 1/\rho_c}$$

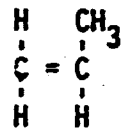
Where θ is the crystalline fraction, V specific volume and ρ density; subscripts a and c stand for the perfectly amorphous and perfectly crystalline phases respectively. The density of the latter phase is usually taken as that of PE single crystals (1.0 gr/cc), while that of the former can be determined by extrapolation of the melt density plot versus temperature to the ambient temperature. Other means of determining the degree of crystallinity are X-ray diffraction, IR absorption, and thermal methods like differential scanning calorimetry.

Although its tensile strength is limited (1200-2000 psi), it has very high impact-and puncture resistance as well as a high ultimate elongation (400-600%). Its Young's modulus is 20,000-30,000 psi. Basically, being a saturated hydrocrabon, it is resistant to acids, alkalies and many organic liquids. It has a relatively high permeability to gases and organic vapors but is quite impermeable to water vapor. It also has very good flow properties and is readily shaped. In the packaging industry, it is extensively used for bags, pouches, bottles and other types of containers. Due to its excellent sealing properties, it is also widely used as the sealable component in laminates.

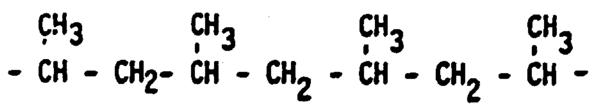
HDPE, is manufactured by the so-called" low pressure" process. Its density is 0.940-0.965 gr/cc. its degree of crystallinity - 65-90%, the melting range of the crystallites - 130-135°C. HDPE is much more rigid than LDPE (Young's modulus ≃ 100,000 psi) and has also a higher tensile strength (3000-4000 psi), but on the other hand its elongation (hence also its toughness) is lower - 100-400%. High - density by polyethylene is also extensively used in the packaging industry, primiarily for bottles and other types of containers. Films of HDPE with lower permeability to gases and water vapor are also available. Recently films of cross-linked polyethylene (both variants) with improved properties became available; they shrink around the packaged product (e.g. poultry meat) and take on its shape on heating. PE films are also used as overwrap for palletized shipping containers to keep them together during transportation. Crosslinked and non-crosslinked polyethylene foams are used as cushioning materials for fragile products in transportation and handling.

Polypropylene. Polypropylene (PP) is another compound of rapidly increasing importance in the packaging industry: in 1978 it had one of the highest rates of consumption growth among polymers, approximately 15%.

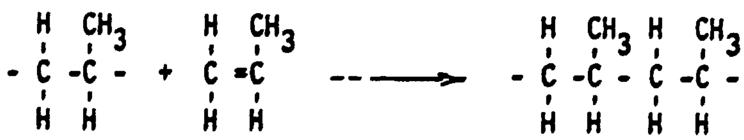
The monomer, propylene, is:



Polymerization is carried out through a stereospecific reaction similar to that of HDPE, resulting in the polymer:

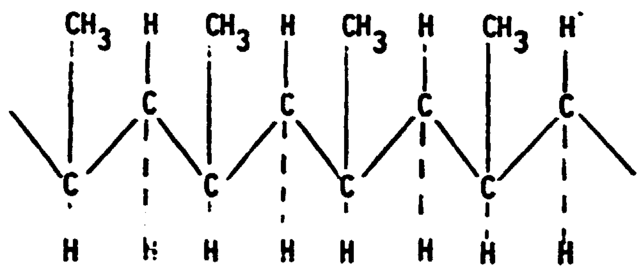


Thus, PP has a single methyl gtoup on each monomeric unit of the backbone. Addition of a monomeric unit can be either head-to-tail:



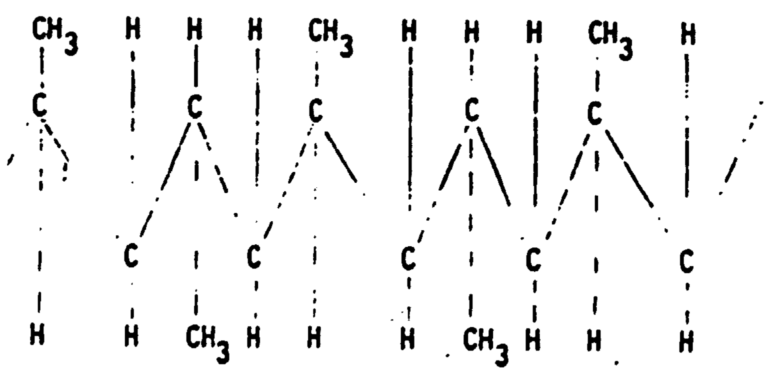
or head-to-head:

Also, as the carbon atom to which the methyl group is attached is asymmetric, polypropylene can assume several different spatial configurations with correspondingly different physical and mechanical properties. In the isotactic form, the methyl groups are confined to one side of the backbone carbon atoms.



isotactic polypropylene

In the syndiotactic form, they lie in alternating regularity above and below the backbone.



syndiotactic polypropylene

in the atactic form, they are arranged at random along the main chain. Atactic PP and other olefin polymers are amorphous, while the isotactic and syndiotactic forms are crystalline.* Accordingly, commercially available polypropylenes are partially crystalline products. Their density is 0.90-0.91 gr/cc- one of the lowest among polymers, and their melting temperature is 160-178^{o}C, thanks to which foods and drugs packaged in PP can be heat-sterilized inside the package, which is not the case with PE. The tensile strength of PP is as high as 4000-6500 psi

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* For further discussion of the steric conformations of olefin polymers, the reader is referred to the excellent book of Raff and Doak (2) .

(depending on grade, molecular weight, density etc.) and in an oriented film may even reach values of 20,000-30,000 psi. The main applications of polypropylene in the packaging industry are as film (mainly biaxially - oriented), in bottles, and other types of containers, and in linerless closures. Due to its very low and constant water vapor transmissibility, PP films replace cellophane in packaging of foods that require a low humidity atmosphere (such as baked and crispy products) as in the case of cellophane this transmissibility changes with time and relative humidity. PP is also used for woven sacks and unifying straps preparation.

Polybutylene. Polybutylene (PB) is relatively new in the packaging industry, but is already finding rapidly expanding use. Its monomer, butylene, is:

$$CH_3 - CH_2 - CH = CH_2$$

and the polymer has the following structure:

$$\begin{array}{ccccccc} CH_3 & & CH_3 & & CH_3 & & \\ | & & | & & | & & \\ CH_2 & & CH_2 & & CH_2 & & \\ | & & | & & | & & \\ -CH & - CH_2 - & CH & - CH_2 - & CH & - CH_2 - & \end{array}$$

i.e. it contains an ethyl group on each monomeric unit of the backbone. Like polypropylene, polybutylene, can assume several spatial configurations and its properties vary accordingly. Commercially-available polybutylenes withstand relatively high temperatures and were thus originally utilized mainly in hot-water distribution systems. PB has also, however, very good properties at low temperatures and high impact-and puncture resistance. The main use of PB film at present is for overwrapping frozen and fresh meat .

Polyvinyl chloride. Polyvinyl chloride (PVC) is obtained from vinyl chloride, $CH_2 = CHCl$ (also referred to as vinyl chlorine monomer, VCM). It is an amorphous transparent compound with the following structure:

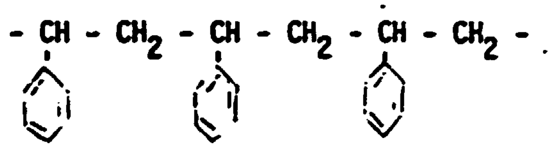
$$\begin{array}{cccccccccc} & Cl & & Cl & & Cl & & Cl & \\ & | & & | & & | & & | & \\ - Ch_2 - & CH & - CH_2 - & CH & - CH_2 - & CH & - CH_2 - & CH & - \end{array}$$

Thus, every second carbon of the backbone contains a chlorine atom which assists in identification of PVC compounds. PVC is rigid at ambient temperatures. Flexibility is imparted to it by incorporation of plasticizers- primarily esters of phthalic, adipic and sebacic acids. It is difficult to process because of its high heat sensitivity, reflected in the onset of decomposition at temperatures above 80^oC, with discoloration and liberation of hydrogen chloride, which is harmful to the processing equipment.

To prevent such decomposition, stabilizers (such as tin-, cadminum-, barium- and lead compounds, epoxides etc.) and lubricants are incorporated. Plasticizers make also for improved processibility.

Rigid and semirigid PVC compounds are used for bottles, jars and other types of containers for dry foods. Plasticized compounds are converted into film and uses as shrink - and stretch overwrapping for palletized containers. In the food industry, PVC film serves as overwrapping for meat products. However, its use for food packaging was inhibited considerably in recent years by the discovery that VCM is a carcinogen. Increased tightening of regulations forced PVC manufacturers to gradual reduction of VMC in their polymers, to levels as low as several parts per billion, which in some cases is a reduction of four to five orders of magnitude compared with the original compounds. However, negligible as this would seem, the actual level below which there is no migration from the polymer to the food is still unknown.

Polystyrene. Polystyrene (PS) is an amorphous transparent polymer produced from styrene (ethylbenzene). The polymer has the following structure :



At room temperature, PS is a hard and brittle material, as it is in the glassy state (its glass transition temperature, T_g, is in the vicinity of 90^oC). For reduced brittleness, styrene is copolymerized with butadiene to yield impact PS (IPS) or high-impact PS (HIPS). It can also be copolymerized with acrylonitrile to yield styrene-acrylonitrile copolymer (SAN). A combination of all three (terpolymer) also exists: acrylonitrile-butadiene-styrene (ABS).

In packaging, polystyrene finds its use primarily in thermoformed trays for backed and meat products and in cups for yogurt, sour cream, and cottage cheese. Thermoformed foamed polystyrene is used in disposable cups for soft and hot beverages. Polystyrene foams are also used as cushioning materials.

Saran.Saran is a copolymer consisting of approximately 85% VCM and 15% vinylidene chloride (or vinyldichloride, $CH_2 = CCl_2$). Its permeability to gases and vapors is very low, and it is referred to accordingly as a high gas-barrier material. Its main packaging application is in laminates and coatings for paper or other plastics with good mechanical but poor barrier properties. These products are widely used for packaging of oxygen and/or moisture-sensitive foods, including frozen meats.

Homopolymers and copolymers of acrylonitrile. The chemical structure of polyacrylonitrile is:

$$-CH_2-\overset{CN}{\overset{|}{CH}}-CH_2-\overset{CN}{\overset{|}{CH}}-CH_2-\overset{CN}{\overset{|}{CH}}-CH_2-\overset{CN}{\overset{|}{CH}}-$$

Thus, every other carbon atom of the backbone has a cyanic group as a side chain.

Like saran, polyacrylonitrile and copolymers of acrylonitrile with methylacrylate, butadiene and other monomers have very good mechanical (including low creep) and barrier properties. An attempt to utilize these properties for manufacturing of family-size carbonated beverage bottles was meanwhile abandonded as the polymer was found to be a carcinogen, but the compounds are still used for dry foods and in laminates where they are not in direct contact with the contents.

Condensation Polymers

Some highly important polymers such as polyesters, polyamides (nylons), polyurethanes and bakelites are obtained through condensation reactions. Condensation polymers are built of monomers with functional groups such as- COOH (acids), - C-OH (alcohols), - NH_2 (amines), etc., and the by-products of the reaction are small molecules such as H_2O, HCl, NaCl, CH_2O (formaldehyde). The number of functional groups is defined as the number of units the monomer is capable of reacting with. Accordingly, the functionality of a double bond or an - NH_2 group is 2; of a- COOH or an - OH group - 1. In order to form a linear or a branched polymer, the functionality of the monomer should be at least 2; for a crosslinked polymer, it should be higher than 2.

<u>Polyesters.</u> When an alcohol is reacted with an acid, an ester is formed, with water as a by-products:

$$R - OH + R_1 - COOH \qquad RCOOR_1 + H_2O$$

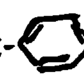
In the case of monofunctional materials, the reaction terminates after the ester has been formed. In the case of diffunctional materials, however, there remain residual acidic and alcoholic groups.

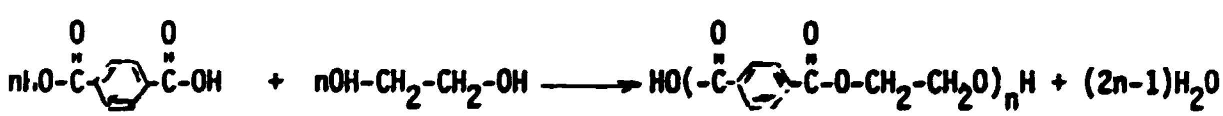
$$HO\overset{O}{\overset{\|}{C}} - R - \overset{O}{\overset{\|}{C}} - OH + HO - R_1 - OH \rightarrow HO - \overset{O}{\overset{\|}{C}} - R - \overset{O}{\overset{\|}{C}} - O - R_1 - OH + H_2O$$

which react further and yield a polyester:

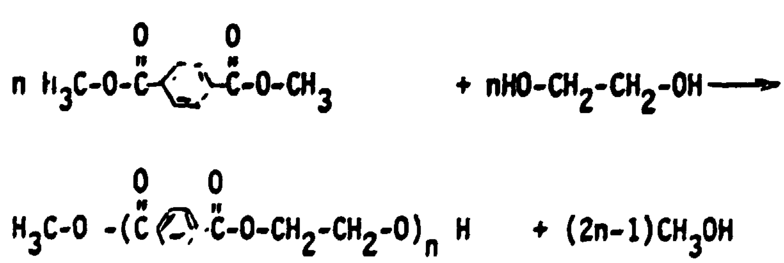
$$nHO-\overset{O}{\overset{\|}{C}}-R-\overset{O}{\overset{\|}{C}}-OH + nHOR_1-OH \xrightarrow{H^{\oplus}} HO-(-\overset{O}{\overset{\|}{C}}-R-\overset{O}{\overset{\|}{C}}-O-R_1-O)_nH + (2n-1)\ H_2O$$

As the reaction is of the equilibrium type, the water has to be removed by vacuum if a high polymer is sought .

For example, if terephthalic acid HOOC--COOH is reacted with ethylene glycol, polyethylene terephthalate (PET) is formed according to the reaction:



The same result is obtainable through trans-esterification, using a diester instead of an diacid. In our example, dimethyl-terephthalate can be used instead of terephthalic acid;



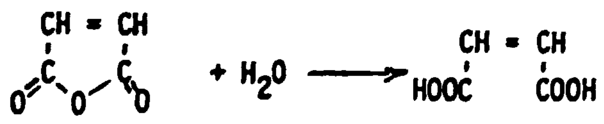
In this case methanol is obtained as a by-product instead of water .

Generally, aromatic saturated acids or esters serve for production of so-called thermoplastics, with good physical properties at ambient temperature (including fibers); by contrast, aliphatic unsaturated acids and esters serve mainly for molding and laminating compounds which are subjected to crosslinking after the product has been shaped, to yield thermosets. The difference bewteen thermoplastics and thermosets may be firefly characterized as follows. Molecules in linear and branched chains can be drawn apart or detached, and the corresponding polymers can thus be dissolved in an appropriate solvent or melted by heat - whence the term " thermoplastic". By contrast, the three-dimensional bonds of a crosslinked compounds prevent separation of the molecules; in other words, the polymer had become stable or "set", and can no longer by dissolved or melted; at elevated temperatures it decomposes or burns up.

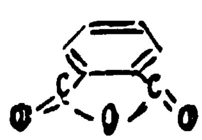
Linear chain Branched chain Crosslinked chains

A thermoplastic can be converted into a thermoset, but not vice versa. Moreover, a thermoplastic can be remelted and reshaped so long as degradation has not occured. The general practice with reprocessed themoplastics is to incorporate 5-10% of it in virgin material.

One of the widely used acids for thermosetic polyester is maleic acid or its anhydride (which is converted into the acid in the presence of water:



Usually a mixture of unsaturated and saturated acids such as adipic $HOO(CH_2)_4$-COOH, azelaic HOOC $(CH_2)_7$ - COOH, and isophthalic acid or its anyhydride,



are used.

The most commonly used alcohols are ethylene and propylene glycol ($HO\text{-}CH_2\text{-}CH_2\text{-}OH;CH_3\text{-}CH(OH)\text{-}CH_2\text{-}OH$). The reaction is carried out in an acidic environment (an acidic catalyst is used) and continues so long as the water is being removed. However, it is also feasible - albeit at a much lower rate even in the absence of a catalyst, as the diffunctional acid itself can serve for that purpose.

PET is the most extensively used polyester in food packaing, thanks to its superior mechanical properties, relatively low permeability to gases, and resistance to elevated temperature. The rate of growth of its consumption is comparable to that of polypropylene, namely 15% in 1978. In the absence, to-day, of any health-hazard contraindications, biaxially-oriented PET has taken the place of acrylonitrile copolymers in production of economy-size (2-liter) bottles for carbonated beverages. A 1-liter bottle for the same purpose (4), and 10- and 22-liter institutional size containers for solids, semisolids or liquids (e.g. pickles), were also recently developed (5). Laminates with PET as one of the components are also very common now in food packaging. PET film is used as the food-contacting phase in ovenable boards (the outer layer being cardboard). PET "boil-in-the-bag" and sterilizable pouches are also quite common.

Other polyesters, including polybutylene terephthalate, and copolyesters, are also in the process of development for the packaging industry, primarily for blister packs (3).

<u>Polyamides (nylons)</u>. When an amine is reacted with an acid, an amide is obtained:

$$R\text{-}CH_2\text{-}NH_2 \quad + HOOC\text{-}R_1 \longrightarrow RCH_2\text{-}NH\text{-}\overset{\overset{O}{\|}}{C}\text{-}OR_1 \quad + H_2O$$

When a diamine reacts with a diacid the result is a polyamide, popularly known as a " nylon":

$$nH_2N\text{-}CH_2\text{-}R\text{-}CH_2\text{-}NH_2 \quad + nHOOC\text{-}R_1\text{-}COOH \longrightarrow$$

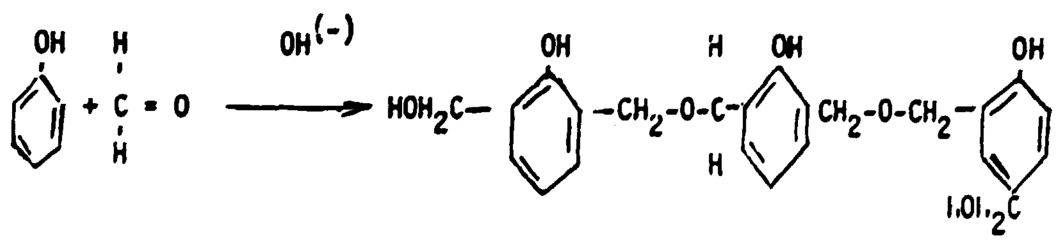
$$H(\text{-}\overset{H}{\overset{|}{N}}\text{-}CH_2\text{-}R\text{-}CH_2\text{-}\overset{H}{\overset{|}{N}}\text{-}\overset{\overset{O}{\|}}{C}\text{-}R_1\text{-}\overset{\overset{O}{\|}}{C})_n OH \quad + 2(n-1)H_2O$$

The product is designated by paired figures, the first standing for the number of carbon atoms in the diamine and the second for these of the diacid. Thus Nylon 6,6 is formed from hexamethylene diamine $H_2N\text{-}(CH_2)_6\text{-}NH_2$ and adipic acid $HOOC(CH_2)_4COOH$, while Nylon 6,10 is formed from the same diamine and sebacic acid $HOOC(CH_2)_8COOH$. Polyamides are also obtainable from an amino acid:

$$n\ H_2N\text{-}R\text{-}COOH \longrightarrow H\text{-}\overset{H}{N}(\text{R-}\overset{O}{C}\text{-NH})_nH + nH_2O$$

in which case the product is designated by a single figure representing the number of carbon atoms in the amino acid; Nylon 6 and 11 are made from $H_2N\text{-}(CH_2)_5\ COOH$ and $H_2N\text{-}(CH_2)_{10}\text{-}COOH$ respectively. The most commonly used compounds in packaging are Nylon 6 and 6,6. Nylons 6,10; 6,12 and 11 are less frequently used. Because of their excellent mechanical properties, the polyamides belong to the class of "engineering polymers": their tensile strength is around 10,000 psi, while in oriented film it may exceed 30,000 psi. Their permeability to oxygen, nitrogen and carbon dioxide is low, but their water vapor transmission rate (WVTR) is high; moreover, they absorb moisture and their mechanical properties deteriorate as a result. In packaging, they are mainly used as film, and especially as laminates with PE-acting as water-vapor barrier and providing sealability. From these laminates, cups are thermoformed for processed-meat packaging. Due to the high melting temperatures of the compounds, foods can be heat-sterilized and cooked inside them.

Phenolic Resins and Amino Resins. Phenolic resins, also called phenoplastics, are formed by a condensation reaction between phenol or its derivatives and formaldehyde. Depending on the kind of catalyst and the mole ratio of formaldehyde to phenol used, two kinds of products are obtained. When the mole ratio exceeds 1 (usually 1.25-2.5/1) and a basic catalyst is used, the polymer is called " Resole":

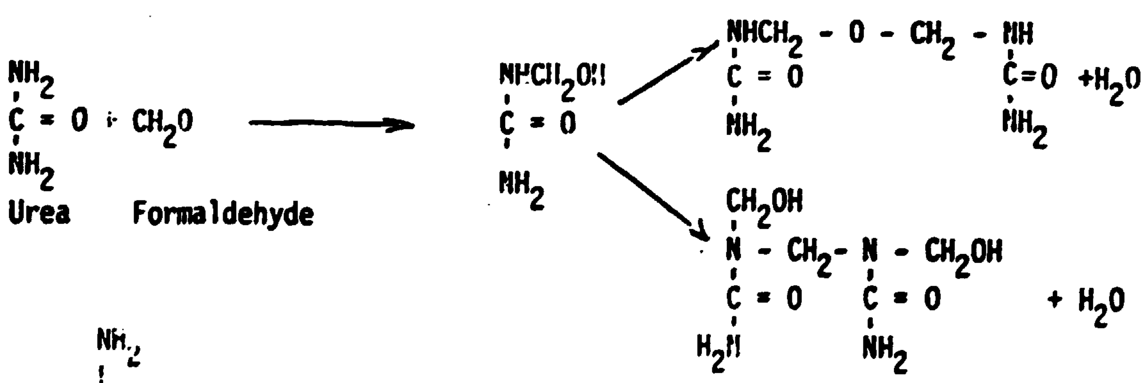


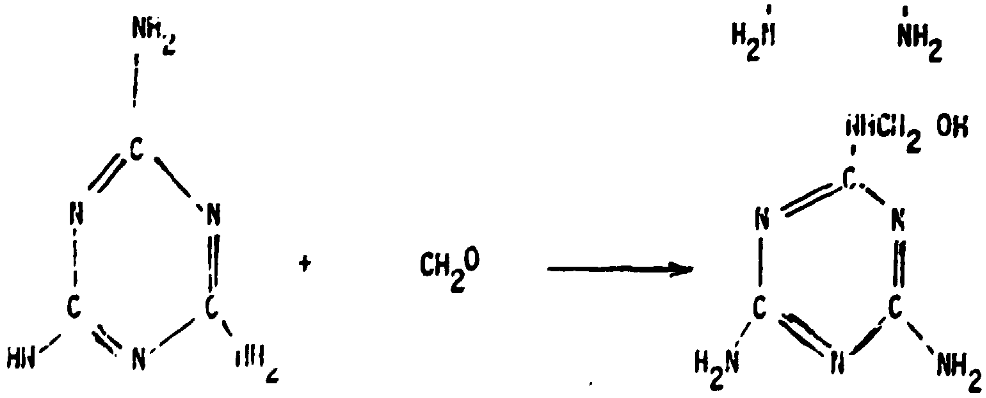
This polymer contains an etheric bond (which is flexible) as well as alcohol groups amenable to curing (crosslinking).

When the formaldhyde/phenol mole ratio is less than 1 (usually 6/7) and an acidic catalyst is used, bonding between the benzene rings is via the methylene groups, and there are no etheric bonds; the result is a stiffer polymer called " Novolac".

Phenolic resins, also known as bakelites, are widely used in varnishes and adhesives and also as molding materials. They have good dimensional and heat stability, as well as good electrical properties (when well cured), and are accordingly used for electrical parts. Their association with packaging is mainly through the epoxy-phenolic category used as lacquers for tin-coated cans.

Amino resins or aminoplastics are obtained by reacting urea or melamine with formaldehyde. The urea-formaldehyde type is more common. Melamine-formaldehydes have better mechanical properties such as hardeness and strength, but are also more expensive.



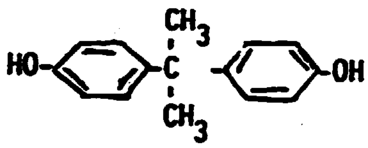


Melamine

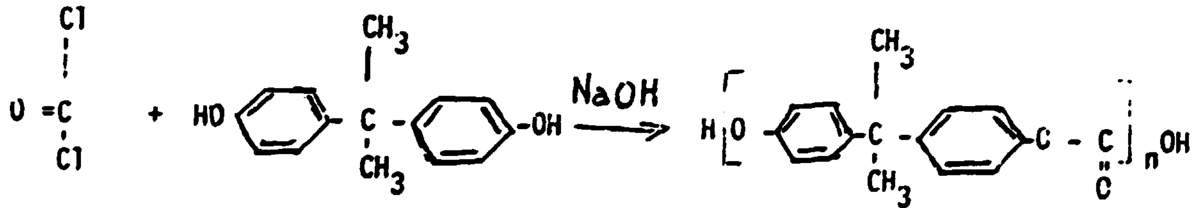
Amino resins have several advantages compared with the phenolic counterparts: they are transparent as well as harder and of better tensile properties, but their resistance to heat, moisture and impact is lower. They are used in adhesives, lacquers and coatings, as molding compounds (with cellulosics as fillers), and for lamination.

<u>Polycarbonates</u>. Polycarbonates are actually polyesters of carbonic acid $O{=}C(OH)_2$, but are classified apart by virtue of the $-O-\overset{O}{\overset{\|}{C}}-O-$ group.

The diglycol used is bisphenol A or 2,2' (4,4' dihydroxyphenyl) - propane:



On occasion, phosgene is used in the polymerization reaction instead of carbonic acid, in the presence of a strong base such as sodium hydroxide. The by-product in this case is sodium chloride (NaCl).

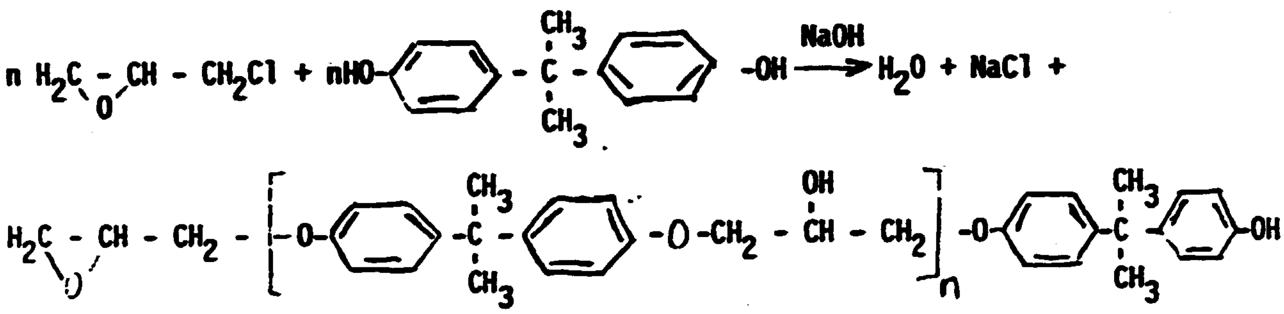


Posgene

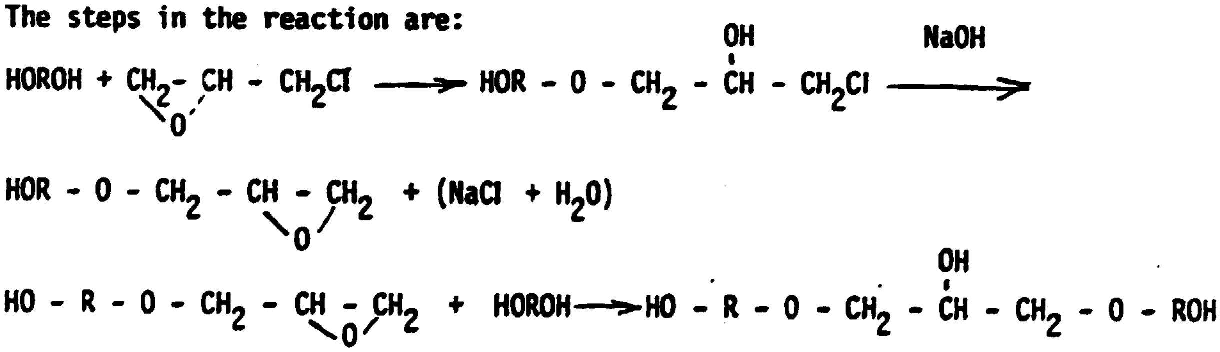
Polycarbonates are among the best polymers as far as properties are concerned. They are transparent, with very high toughness and impact strength, high tensile strength (8500-9000 psi) and modulus (345,000 psi), good heat and dimensional stability, and due to their high softening range (290-305°C) can be used continuously at 140-150°C. Another advantage is that they are self-extinguishing, i.e. they do not burn . Their main disadvantages are high cost and poor weather-and scratch resistance. Also, they absorb moisture, with resulting deterioration of mechanical properties and processibility (as is the case with the polyamides). They are used as substitute for pane glass (e.g. in schools and prisons), for parts of telephones, lamps, safety equipment (helmets), baby bottles, etc. In packaging industry, a half gallon returnable container made of polycarbonate was introduced recently for storage of milk, juices and other liquids (6), but failed to find widespread use because of high cost, handling problems, and health hazards due to misuse by consumers (e.g. unauthorized storage of chemicals)..

Polycarbonate film has also been commercialized recently.

<u>Epoxy resins</u>. Epoxy resins are condensation products* of a dialcohol (most commonly disphenol A) and epichlorohydrin:



The steps in the reaction are:



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* In reality, they are poly-ethers and their name derives from the starting material and the residual epoxide groups $H_2C-CH-CH_2$ present before crosslinking.

It is seen that with an excess of alcohol, the chain terminates in alcoholic groups, and with an excess of epichlorohydrin - in epoxide groups. The latter is usually the case, as epoxide groups are capable of crosslinking at a later stage(crosslinking via the alcoholic groups is also possible, but because of steric effects is much easier through a terminal - OH group than through one on the backbone). Again, with an excess of epichlorohydrin, the molecular weight of the prepolymer is in the range of 900-3000. Lower molecular weight prepolymers are viscous liquids, while high - MW ones are brittle solids with a high melting point.

Crosslinking via the epoxide group is feasible by polyamines, polyamides and urea-formaldehyde, and via the alcoholic group - by diamines, diacids and anhydrides . The reaction with amines is carried out by opening the epoxide ring:

$$R\text{-}CH_2\text{-}\underset{\diagdown O \diagup}{CH\text{-}CH_2} + R_1NH_2 \longrightarrow R\text{-}CH_2\text{-}\overset{OH}{Ch}\text{-}CH_2\text{-}\underset{\uparrow}{NH}R_1$$

The other hydrogen from the amine (indicated by the arrow) can react with an additional chain.

Epoxy resins are used as binders for metals and other materials, as surface coatings and as molding materials, expecially where glass fibers serve as reinforcing agents. They are also used in the paint industry and as stabilizers for PVC. They have better mechanical properties and resistance to chemicals than polyesters, but are also more expensive. As mentioned earlier, epoxy-phenolic laquers are used for tin-coated cans in the food industry.

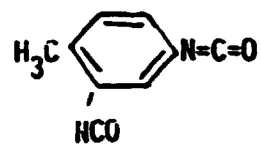
Polyurethanes. Polyurethanes are polymers based on the urethane group $-\underset{H}{N}-\overset{}{\underset{O}{C}}-O$ and usually obtained by reacting a glycol with a diisocyanate:

$$nHO\text{-}R_1\text{-}OH + n\ O{=}C{=}N\text{-}R\text{-}N{=}C{=}O \longrightarrow -(O\text{-}\overset{O}{C}\text{-}\overset{H}{N}\text{-}R\text{-}\overset{H}{N}\text{-}\overset{O}{C}\text{-}R_1)_nOH$$

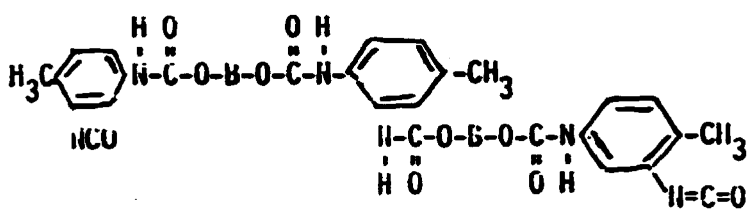
diisocynate

The polymers so obtained have several forms:

a) Elastomers (rubber-like materials). Elastomers are prepared in several steps. In the first step a low- MW (1000-2000) prepolymer "B" is prepared - e.g. a polyester containing terminal alcoholic groups. In the second step, the prepolymer is reacted with an aromatic diisocynanate, usually toluene diisocyanate,



and the resulting polymer (already an elastomer) is capable of crosslinking:



The crosslinking reaction is carried out via the isocyanate groups by diamines, dialcohols, diacids, etc. Elastomeric polyurethanes are friction-resistant and highly resistant to solvents and fats, and possess also very good elastic properteis.

b) Foams. As above, a low- MW prepolymer with terminal alcoholic groups is prepared and reacted with diisocyanate. With an excess of diiso- - cyanate, it reacts with the water formed in the condensation reaction and releases carbon dioxide, CO_2, which causes the polymer to foam during the crosslinking reaction:

$$R-N=C=O \quad + H_2O \longrightarrow R-NH_2 \quad + CO_2$$

$$R'-N=C=O \quad + RNH_2 \longrightarrow R'-\underset{H}{\underset{|}{N}}-\overset{O}{\overset{\|}{C}}-O-NHR$$

A difunctional polymer yields a flexible foam, and a polyfunctional one- a rigid foam, the rigidity increasing with crosslink density. Sometimes inert liquids with a low boiling point, such as freons, are incorporated in the polymer and expedite the foaming process. Catalysts are used to regulate formation of CO_2 and the crosslinking reaction. In the packaging industry, the foams are used as shock isolating and cushioning materials.

c) Fibers. Polyurethane fibers are of high elasticity and are used in bathing- and diving suits.

d) Coating and adhesive. Polyurethane- based coatings are resistant to abrasion and to solvents. They are flexible and of high impact resistance. They can be applied as a spray, by brushing and by dipping. Polyurethane adhesives are commonly used as the binding layer in laminates.

For a more detailed description of the structure and properties of polymers, the reader is referred to the relevant literature (7-10) .

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2. Raff, R.A. and Doak, K.W. "Crystalline Olefin Polymers", Interscience, N.Y. (196
3. Evans, D.P., Packaging Engineering 24, (5), 59 (1979).
4. Murray, T.A., Modern Packaging, 52, (2), 43 (1979).
5. Murray, T.A., Modern Packaging, 52, (7), 4 (1979).
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7. Flory, P.J., " Principles of Polymer Chemistry", Cornell Univ. Press, Ithaca (1953).
8. Schildknecht, C.E., " Polymer Process", Interscience, N.Y. (1956).
9. Jenkins, A.D. and Ledwith, A., " Reactivity, Mechanism and Structure of Polymer Chemistry", John Wiley (1974).
10. Miller, M.L., " The Structure of Polymers", Reinhold, N.Y. (1966).

ANNEX II

Curso: Polymers for Food Packaging: Structure and Properties

Período: de 07 a 23 de janeiro de 1986, toda terça e quinta-feira.

Horário: de 08:00 às 11:30 horas

Carga Horária: 21 horas

Professor: Dr. Joseph Miltz

Consultor da ONUDI na área de materiais plásticos de embalagem

Coordenação técnica: Marisa Padula

Participantes:

1. Assis Euzébio Garcia
2. Claire I.G. de L. Sarantópoulos
3. Elizabeth de F.G. Ardito
4. Eloisa Elena Correa Garcia
5. Lea Marisa de Oliveira
6. Maria Helena C. Fernandes
7. Edina Hiroko Takemura
8. Gina M. Bueno Quirino
9. Gislene Capovilla
10. Jane Barbutti
11. Maria Angélica Vênega
12. Pedro Fran-isco Moreira

Programa

1. Structure of addition and condensation polymers.

2. Effect of molecular weight and molecular weight distribution on properties (flow, mechanical).

3. Manufacturing of packages: extrusion, extrusion blow, injection blow molding; rotational molding, coextrusion, coating and lamination.

4. New packaging materials and structures.

5. Permeability and Migration.

6. Package - Product interaction.

7. Paper and Paperboard.

8. Transport.

ANNEX III

LIST OF RECOMMENDED BOOK

1. CROSBY, N.T.

Food Packaging Materials Applied Science Publ. (1981)

2. BRANDRUP & IMMERGUT

Polymer Handbook

2nd Eddition, John Wiley (1976)

3. BRISTON, J.H. and KATAN, L.L.

Plastics in Contact with Food, London Food Trade Press Ltd (1974)

(7 Garrick St. WC 2E9A5 , London)

4. RAYMOND B. SEYMOUR

Additives for Plastcs

Academic Press (1978) Vol. I + II

5. FERDINANDO RODRIGUEZ

Principles of Polymer Systems

McGraw Hill (1976)

6. BILLMEYER, F. W. Jr.

Textbook of Polymer Science

2nd Ed. Wiley Interscience (1971)

7. KAUFMAN, S.H.

Introduction to Polymer Science

John Wiley (1976)

8. HANLON, J.F.
Handbook of Package Engineering
McGraw Hill (1971)

9. HASLAM, J, & WILLIS, H.A.
Identification and Analysis of Plastics. Van Norstrand Co.
Princeton N.J. Latest Ed.

10. CRANK, J.
The Matematics of Diffusion
Clarendon Press, Oxford (1975)

Embalagem Plástica para Alimentos: Interação, Migração e Tendências.

Palestrante convidado:

Dr. Joseph Miltz

- Technion - Israel Institute of Technology

Dept. of Food Engineering & Biotechnology

- Atualmente:

Professor visitante da School of Packaging-Michigan State University

- Consultor da ONUDI em materiais plásticos de embalagem para alimentos no projeto BRA/82/030. CETEA/ITAL.

Idioma: inglês

Data: 28/01/86

Taxa: Cr$ 150.000

PROGRAMA

08:00 - 09:00	- Inscrição
09:00 - 09:30	- Apresentação das atividades do Grupo de Polímeros e Celulósicos do Projeto BRA/82/030 - CETEA/ITAL.
09:30 - 10:30	- Permeabilidade e migração de Materiais Plásticos de Embalagem
10:30 - 10:45	- Café
10:45 - 12:00	- Alterações nos produtos alimentícios devido ao contato com polietileno
12:00 - 14:00	- Almoço
14:00 - 14:45	- Estudo dos compostos de termodegradação formados durante a extrusão de políemros. CETEA/ITAL.
14:45 - 15:45	- Reciclagem de Plásticos
15:45 - 16:00	- Café
16:00 - 17:00	- Novas estruturas e materiais de embalagem
17:00 - 17:30	- Discussão e encerramento
17:30	- Coquetel

MINUTA

Campinas, 07 de janeiro de 1986

Assunto: Seminário: "Embalagem Plástica para Alimentos: Interação, Migração e Tendências".

Prezado Senhor,

Esta diretoria tem o prazer de comunicar a V.Sa. que será realizado neste Instituto, no dia 28 de janeiro de 1986 o Seminário "Embalagem Plástica para Alimentos: Interação, Migração e Tendências".

O referido seminário será apresentado pelo Dr. Joseph Miltz, consultor da ONUDI em embalagens plásticas, contratado por um mês pelo projeto BRA/82/030 ora em existência no ITAL.

Durante a realização deste evento serão tratados assuntos técnicos sobre a interação embalagem-alimento, assim como as tendências de materiais plásticos de embalagem.

Anexados à presente, estamos enviando a V.Sa. o programa do Seminário, a ficha de inscrição, bem como a relação dos principais hotéis em Campinas. Havendo interesse, solicitamos a gentileza de preencher a ficha de inscrição e devolvê-la com urgência ao Setor de Treinamento do ITAL. Para maior facilidade, a inscrição poderá ser feita por telefone e o pagamento da inscrição remetido pelo correio.

Comunicamos ainda que o período de 08:00 às 09:00 do dia 28 será destinado à formalização das inscrições.

Este Seminário terá a co-participação da Sociedade Brasileira de Ciência e Tecnologia de Alimentos - SBCTA.

Atenciosas Saudações

RODRIGO OTÁVIO TEIXEIRA NETO
DIRETOR GERAL
ITAL

Anexos: Programa, ficha de inscrição,
e relação de hoteis.

ANNEX V

LIST OF RECOMMENDED EQUIPMENT

1. An instrument for the determination of the melting point of semicrystalline polymers. One instrument that can very well serve this purpose in the "Fisher Johns Melting Point Apparatus" Catalog no. 12-144.

2. A Melt Flow Indexer
   One instruments that is relatively cheap and has good performance is the "Ray-Ran" Model MK2 or Model 2A.
   This instrument is manufactured in England and is distributted in the USA by Testing Machines Inc (TMI) 400 Bayview Ave., Amityville, N.Y. 11701 Tel. (516) 842-5400.

3. A holder for the Concora Liner Test (CLT) for measuring the compressive resistance of the liners in corrugated board.

4. A Laboratory Concora Corrugator.

5. A holder for the Concora Crush Test (CCT)

6. A compression (Crush) Tester for Corrugated boxes.

If it is decided that CETEA has to enter also to the field of Transport, the following additional pieces of equipment should be acquired (according to the authors priority).

7. A Vibration System

MTS has several models of Vibration Systems. The one that is recommended is model 840 with a table of approximately 1.5X1.5 meters in size.

8. A Drop Tester

9. A Transportation Simulator

The author has in his Packaging Laboratory a system made by LAB with which he is very satisfied. The size of the platform is about 2 X 2 meters.

10. The Shock Tester in the author's Packaging Laboratory is of the type with two air cylinders and plastic programmmes (approximately 1.5 X 1.5 meters in size) made by MTS. This instrument works well.