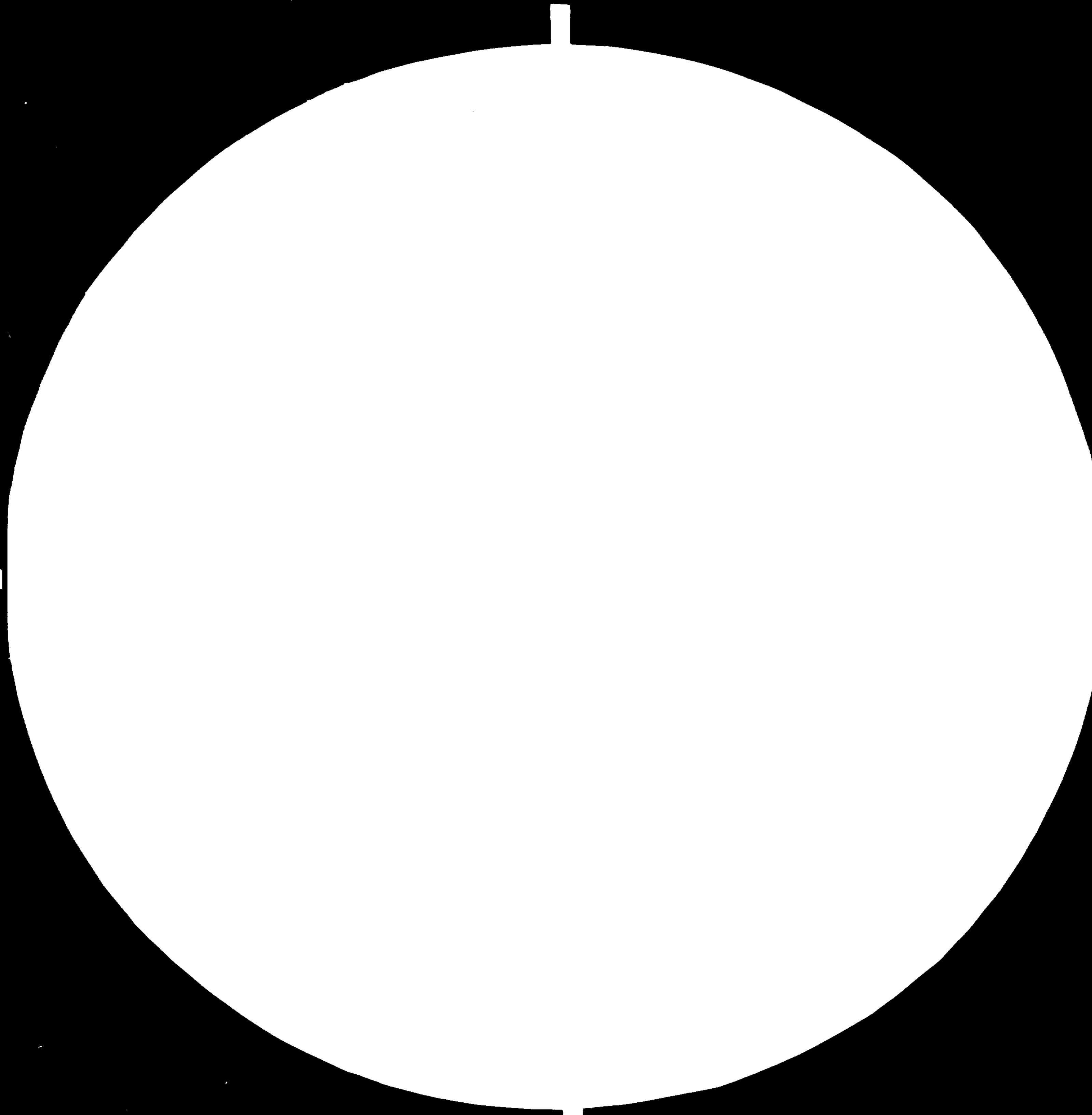

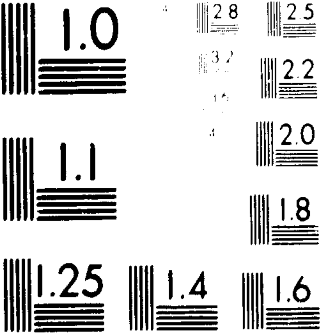

MICROCOPY RESOLUTION TEST CHART

10861

DRAFT
JULY 1981

ASSISTANCE TO THE PLASTICS INDUSTRY

CYPRUS

(SI/CYP/79/802)

Project findings and recommendations

Third technical report prepared for the Government of Cyprus

by

Danny Clarke

expert of the United Nations Industrial Development Organisation acting as Executing Agency for the United Nations Development Programme

Contents

Abbreviations

CYS Cyprus Standards Organisation

LD.PE Low density polyethylene

GSL General State Laboratory (Formerly Government Laboratory)

1. Summary

A technical report has been prepared (Annex A) setting out the results of the long life film trials. Although a film with three seasons continuous use was not obtained at the concentrations of additives tested nevertheless the results were extremely interesting and a formulation capable of making a film with two seasons continuous use has been established.

Arrangements for extending this research development programme to achieve a film with three seasons use (three year film) have been put in hand and further UNIDO assistance will be required to provide consultancy service.

Training has been given to counterparts in carrying out Elmendorf tear and dart impact testing. Assistance has also been given to the Cyprus Standards Organisation.

Six recommendations have been made.

2. Recommendations

The following recommendations are respectfully submitted to Government for their consideration and implementation.

It is strongly recommended that -

1. The technical report (Annex A) should be circulated to the Cyprus plastics industry and to other interested organisations so that they are fully informed of the results of the first series of trials, as well as being made aware of the support and assistance that is being provided to the industry by the Ministry of Commerce and Industry.

2. Arrangements should be made for Mr. George Kathijodis of the State General Laboratory, who is responsible for the plastics testing laboratory work, to assist the programme co-ordinator Mr. George Michaeloudes of CYS in the execution of the extension of the research development programme for long-life film as this will considerably benefit in widening his knowledge base of plastics through first-hand experience.

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3. UNIDO should be requested to provide the services of the expert for a further 3 m/m on a split mission basis, with the first part in April/May 1982 and the second part in October/November 1982 to provide general coordination and assessment of the extended research development programme, to provide training in tensile strength and elongation at break testing and use of the density column, to provide assistance in developing experience in tear and impact testing, and to provide assistance to CYS in training in the use of the Vicat softening point apparatus.

   This assistance should be requested as an SIS basis.

4. CYS should purchase both a hand-model and bench model, lever-operated, dial gauge thickness meter for plastics film (20 - 400 microns) to comply with the requirements detailed in BS Standard 2782 Part 3: 1970 Method 301 D.

5. Mr. R.L. Symeon, Director of the Department of General State Laboratory, should make official application for the nomination of Mr. George Kathijodis for fellowship to participate in the UNIDO-LKT plastics training course in Vienna 1981. This request should be made through the Ministry of Commerce and Industry so that the fellowship can be considered for funding through the on-going UNIDO project DP/CYP/76/004.

6. Mr. George Michaeloudes should be nominated for fellowship on training in drafting of plastics standards, and that UNIDO should be requested to arrange such a training course. He should also be nominated for fellowship to the 1982 UNIDO-LKT plastics training course to widen his plastics technology base which would greatly assist his standards work.

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3. Introduction

This one month mission was to continue the work concerned with the development of long life films for agricultural use, and to train personnel in the use of testing apparatus which will be used for measuring physical property changes taking place in the experimental films after exposure.

The expert was attached to the Ministry of Commerce and Industry and Mr. George Michaeloudes was allocated as counterpart. Mr. George Kathidjiotis, at the General State Laboratory where a plastics testing laboratory is being developed, also acted as counterpart.

The expert arrived in Cyprus on 17 May and left on 15 July, 1981.

4. Findings

a) Long life film trials results

A technical report entitled 'Development of a long life low-density polyethylene film for greenhouse covering' has been prepared with the active assistance of Mr. George Michaeloudes and is attached as Annex A.

The exposure trials were terminated in April 1981 after a period of two years, when all the samples had shattered. Although a film with a three year life had not been achieved at the additive concentrations tested the trials however did show that a formulation containing 1.5% of additive Tinuvin MB 192* would be capable of providing two seasons use in continuous exposure conditions. This is more than double the life of film without additive.

The report concludes that an extension of this small research development programme should be undertaken so that the objective of finding a film formulation with a life of three years (or more) can be achieved.

To this end consultations have been undertaken with all the participating organisations and there is full agreement that they are prepared to offer all the facilities needed to execute this extension of the programme.

* Representing 0.3% active ingredients

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It is strongly recommended that the technical report (Annex A) should be circulated to the Cyprus plastics industry and to other organisations so that they are fully informed of the results of the trials as well as being made aware of the support that is being provided to the industry by the Ministry of Commerce and Industry.

b) Extension of the research development programme for long life film

The technical details relating to the extension of these trials are set out in Annex B.

Three formulations will be prepared based on master batch additive. The number of samples of film to be exposed per exposure period has been increased from two to three. The frequency of removing samples has been increased in the third year and subsequent years.

Film of each formulation will be used to cover the complete roof of a greenhouse, and three greenhouses are being made available for this purpose.

Tensile strength and elongation at break testing will be added to the other tests to be performed on the film.

Arrangements are currently in hand for shipment of some MB 192 master batch additive.

Production of the three film formulations are expected to start after mid-August, subject to the arrival of the masterbatch, and the covering of the greenhouses and the special roof unit are expected to take place in October/November 1981 period. These operations will be organised and supervised by Mr. George Michaeloudes.

It would be of considerable benefit in widening the plastics technology base of Mr. George Kathidjiodis if he were also to assist in these operations. It is therefore strongly recommended that arrangements be made for Mr. George Kathidjiodis of the State General Laboratory, who is responsible for the plastics testing laboratory work, to assist the

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programme co-ordinator, Mr. George Michaeloudes of CYS in the execution of the extension of this research development programme for long-life film as this will considerably benefit in widening his knowledge base of plastics technology through first hand experience.

Further UNIDO consultancy assistance will be required in 1982 when the first and second sets of exposed samples are removed from the exposure roof unit (April/May and October/November 1982) to provide general coordination and assessment of the extended research development programme, to provide training in tensile strength and elongation at break testing, and use of the density column, to provision of assistance in developing experience in tear and impact testing, and to provide assistance to CYS in training in the use of the Vicat Softening point apparatus.

It is therefore strongly recommended that UNIDO should be requested to provide the expert for 3 m/m on a split mission basis with the first part in April/May 1982 and the second part in October/November 1982. This assistance should be requested on an SIS basis.

c) Physical tests and training

The Elmendorf tear test apparatus, the dart impact tester and the density column had been assembled and checked by the counterparts on the arrival of the expert.

The density column showed a water leak at the intesface of the copper pipe and Perspex wall of the container. This requires new washers fitting. Unfortunately the cooling of the apparatus is designed for use with tap water below 23C. In Nicosia the water temperature is about 28-30C so some form of refrigeration will be required for the permanent installation of this apparatus. The use of external ice cooling of the top water will achieve a temporary solution, but this apparatus should be run on a non-stop basis so that it is available for use at any time.

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A request has been passed through Mr. Majumdar to PAC, UNIDO Vienna to ascertain the manufacturers specific recommendations. Assistance has also been given to CYS on equipment suppliers and specifications.

A suitable dial gauge thickness meter, specifically for measuring film and sheeting thickness was not available, but a suitable hand-model dial gauge, complying with the appropriate BS standard for film measurement, has now been located in Cyprus. A bench model ought also to be purchased. Use was made of a hand-screw micrometer in the absence of the dial gauge unit.

It is therefore recommended that CYS should purchase both a hand-model and bench-model lever-operated dial gauge thickness meter for plastics film to comply with the requirements of BS Standard 2782 Part 3: 1970 Method 301D.

Training has been given in the use of the tear and impact testers to both counterparts. As only small sized samples were available it was necessary to modify the area of sample exposed for impact testing and a suitable attachment was prepared and utilized.

Both counterparts responded well to training and are able to utilise this apparatus on their own. Much more experience has yet to be gained for the interpretation of results to be fully understood and further training in this aspect of the work is required.

Mr. George Kathidjiodis of the General State Laboratory (GSL) is a food chemist, graduated in USA and holding an MSc. He has been made responsible for the plastics testing laboratory by Mr. R.L. Symeon, Director of GSL. To assist Mr. Kathidjiodis in the execution of his duties it is evident that he requires his knowledge of plastics technology to be broadened. He ought therefore to receive training both in general plastics technology, and to receive practical, first-hand, training in a plastics testing laboratory where he could also have the opportunity of technical discussions regarding interpretation of results.

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UNIDO run a basic plastics technology course at the IKT in Vienna with financial assistance of the Austrian Government. The course is normally nine weeks duration starting in October. Unfortunately invitations were not sent to the Cyprus Government, but the expert has been informed that, if interested, the Government can send participants from any on-going UNIDO project provided funds are available. It is therefore strongly recommended that Mr. R.I. Symeon, Director of the Department of General State Laboratory should make official application for the nomination of Mr. George Kathidjiodis for fellowship to participate the UNIDO-IKT plastics training course in Vienna 1981. This request should be made through the Ministry of Commerce and Industry so that it can be considered under the on-going UNIDO project DP/CYP/76/004 for funding.

The expert has undertaken to ascertain if a course on plastics testing is available through UNIDO.

Mr. George Michaeloudes anticipates that work on drafting plastics standards will start this year. Drafting of standards is a specialised operation and while Mr. Michaeloudes shows an excellent appreciation and understanding of plastics gained from this research programme he does not appear to have received any specific training in drafting plastics standards. It is therefore strongly recommended that Mr. George Michaeloudes should be nominated for fellowship on training in drafting of plastics standards, and that UNIDO should be requested to arrange such a training course. He should also be nominated for fellowship to the 1982 UNIDO-IKT plastics training course to widen his plastics technology base which would greatly assist his standards work.

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5. Acknowledgements

The expert wishes to extend his sincere thanks for all the help and assistance rendered to him both from the Industry Section and the Cyprus Standard Section of the Ministry of Commerce and Industry. In particular to Mr. Akis Papadopoulos, Mr. St. Vassiliou, and Mr. A. Athanassiades and his office staff for their kind support actives, and to other staff members of the Ministry who have contributed to this mission operations.

Sincere thanks and appreciation are recorded to the two counterparts Mr. George Michaeloudes, programme co-ordinator, of CYS and Mr. George Kathijiodis of the State General Laboratory for their active support and full co-operation. Acknowledgements are also due to Mr. P.I. Symeon Director of the Department of General State Laboratory for the active interest he has taken in the mission activities.

Thanks are also expressed to Mr. D. Majumdar, UNIDO project leader, for his valuable advice and assistance and also to his staff for their kind and efficient co-operation which was much appreciated.

Acknowledgement is made to Dr. Krentos, Director of the Agricultural Research Institution and particularly to Dr. C. Olympios and his staff for their active and full support given to this mission which has been very much appreciated.

Thanks are also expressed to the staff of the UNDP Office for their support and assistance given to the expert. Thanks are also due to the various staff members in UNIDO whose back-up services and assistance has been much appreciated.

ANNEX A

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

TECHNICAL REPORT

DEVELOPMENT OF A LONG-LIFE LOW-DENSITY POLYETHYLENE FILM FOR GREENHOUSE COVERING

A co-operative programme with the participation of the Ministry of Commerce and Industry Ministry of Agriculture and Natural Resources General State Laboratory and the Cyprus Plastics Industry.

by A.D. Clarke
UNIDO expert

and George Michaeloudes
CYS Officer.
and project co-ordinator

July 1981

1. Introduction

In 1978 a number of problems arising from the use of locally produced plastics products in agricultural applications were identified. This indicated a need for assistance in up-grading the local plastics technology. One of these problems was the limited life of low density polyethylene film used for greenhouse covering which would normally last for one season and sometimes less.

The greenhouses, using unmodified low density polyethylene (LD.PE) film, mainly of 180 micron thickness in widths up to 6 m. were covered in the September/October period and the film removed in April/May, by which time it had embrittled and generally was not useable for a second season covering.

The cost of film for covering 1,000 square metres of greenhouse area was £C 143 in 1978 and in January 1981 had risen to £C 167 while the cost of labour and other incidents had risen from £C 80 to £C 90 in the same period. It was clearly evident that if a LD.PE film could be developed which would last three years of continuous exposure (Winter/Summer/Winter/Summer/Winter) thus eliminating the need to re-cover annually, then there would be a substantial cost-benefit deriving to the growers. In addition, the development of such a 'long-life' film would open up potential export markets for the plastics film processors.

LD.PE film is progressively degraded by the action of the Ultra-Violet (U.V.) light emitted by solar radiation. One method of reducing this degradation is to incorporate chemical additives into the film which have a specific capacity to preferentially absorb this U.V. energy. It has been standard commercial practice for several years in many countries to use an additive system containing a nickel complexing agent. Unfortunately this additive system has a strictly limited compatibility with LD.PE and increasing the quantity beyond this compatibility level does not produce any increase in the life of the film. With the very high level of solar radiation in Cyprus this type of system would have limited effect.

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A new type of additive which functions in a different manner in absorbing U.V. energy was conveniently just becoming available in small development quantities at this time. The additive in powder-form, known as Tinuvin 622, is a polymeric light stabilizer of the hindered amine class. It possesses good compatibility with LD.PE as well as having low volatility and low migration tendency. It is produced by Ciba Geigy Co. and covered by world patents.

Since the use of this new type of additive had the potentiality to produce a long-life film of three season's use it was decided that it would be highly desirable to carry out a small research development programme to evaluate outdoor weathering performance of some LD.PE films based on differing levels of this additive. During the course of this work additional information was received which showed that the inclusion of equal parts of an additive, benzophenone, produced a synergistic effect in the film. This additive was made available to the project in master batch form under reference G 19-20 so that additional formulations could be evaluated. This is now available as Tinuvin master batch ME 192.

2. Organisation of the research programme

Since there are no central research and development facilities for the plastics industry in Cyprus an officer of the Industrial Extension Service of the Ministry of Commerce and Industry undertook the role of co-ordinator, with the assistance of a UNIDO expert, to interest various organisations whose participation, activity and facilities were required for the successful execution of this small research programme.

The Agricultural Research Institute of the Ministry of Agriculture and Natural Resources offered to provide a specially made roof unit on which samples of the film could be attached and progressively removed at six month intervals so that measurements in the change of performance of the exposed film could then be undertaken. This roof unit was located on a greenhouse at the Agricultural Experimental Station at Akhelia and personnel were provided to assist in the project operations.

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The Cyprus Standards Organisation (CYS) expressed an interest in this work, and they were able to provide, through their UNIDO project DP/CYP/76/004, a tear tester, impact tester, melt flow indexer and a density column. By this means it became possible to examine the change of tear and impact strength with time of exposure as well as the melt flow index. This testing equipment will find continuous use by CYS in the general evaluation of films for various applications and for quality control use when standards have been evolved.

This particular research programme will, in fact, provide very useful background data which is required before any agricultural film standard can be developed.

The testing equipment was located at the Government Laboratory, now re-named the General State Laboratory (GSL) where a plastics testing laboratory is being developed. The GSL made personnel available to undertake the testing required on the samples, and the Ministry of Commerce and Industry provided a UNIDO expert to train personnel in the testing procedures.

It now remained to find facilities to produce the film samples. Following discussions with various plastics processing companies United Plastics (Lordos) Ltd., at Limassol and Cosmoplastics Ltd., at Paphos both offered the free use of their production processing facilities to produce the film formulations required for these trials, and, additionally, provided all the film produced on a free of charge basis. Ciba-Geigy Ltd., kindly provided, free of charge, quantities of both types of their additive in order to assist the execution of this research programme, and they also undertook analysis of the film samples and accelerated ageing tests.

3. Research Programme

Eight different film formulations were produced, including a control film with no additive, all based on LD.PE polymer of commercial grade Melt Flow Index (MFI) 0.2 quality. Film thickness was a nominal 200 microns. Based on available data four levels of additive were selected 0.15%, 0.2%, 0.3% and 0.4%. This is the level of active ingredients with both types of additive.

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Unfortunately, in the trials involving the use of master batch there was insufficient material to execute the 0.4% film formulation. Formulations using Tinuvin 622 were coded additive 'A' and those using master batch G 19-20 coded additive B.

The samples were placed in randomly selected positions on the roof unit and held in place by wooden battens. The outdoor roof exposure/weathering ticals were started in April 1979 and precoded sets of samples were removed at approximately six monthl intervals. Each trial was terminated when the samples had shattered.

4. Results of exposure/weathering ticals

The trials were terminated at the end of two years, in April 1981, when all the samples had shattered.

In December 1979, shortly after the first six-monthly samples had been removed, a severe hail-storm occurred and all remaining samples in the roof-unit of the control formulation (no additive) and of the formulation containing 0.15% of Tinuvin 622 were totally shattered thus terminating their exposure period. The fact that the remaining samples of the other formulations withstood this storm indicates that they had not, at that period, embrittled as much as the ones which shattered.

Twelve months later in November 1980 four of the remaining six formulations had all shattered, and only small pieces of sample film were available for testing. The two remaining sets of samples relating to formulations containing 0.2% and 0.3% of master batch additive had some panels which had shattered.

Formulation 0.2% B had 8 samples intact out of 14
Formulation 0.3% B had 12 samples intact out of 14.

In April 1981 samples of these last two formations had all shattered and there was insufficient material to carry out any tests.

The trials were then terminated.

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5. Results of physical tests

Melt flow index, Elmendorf tear and dart impact strength were measured on the samples before exposure, and also on the samples after each period of six months exposure.

The percentage retention of both tear and impact strength with time of exposure gives a more meaningful comparison of the changes taking place in the film. These have been presented in block form in Figure I and show the retention of strength with different additive levels.

This clearly shows that in the effective levels of additive there is little initial drop in the strength of the film, it then falls steadily and finally the drop is extremely rapid.

6. Tear Strength

The tear strength of the samples relative to time of exposure are detailed in Table No.4, and the percentage retention of the original tear strength with time of exposure are set out in Table No.1.

This shows there had been a severe drop in the retention of tear strength of the control and 0.15% A at the December 79 period when the hail shattered the samples. By comparison the six month figures for the additive A series was within the range of 54-64% retention of original tear strength while the B series show a higher range at 74-100%. The twelve month figures show a continuous deterioration of retention of tear strength, the A series 35-59% being worse than the B series 44-74%. By the eighteen month period the retention of tear strength had dropped severely 2-18% for the A series and 15-24% for the B series.

As mentioned earlier sheets containing 0.2% B and 0.3% B additive were still intact at this point in time although a few had shattered. By the twenty fourth month period both these formulations had completely shattered and there was insufficient material left for testing.

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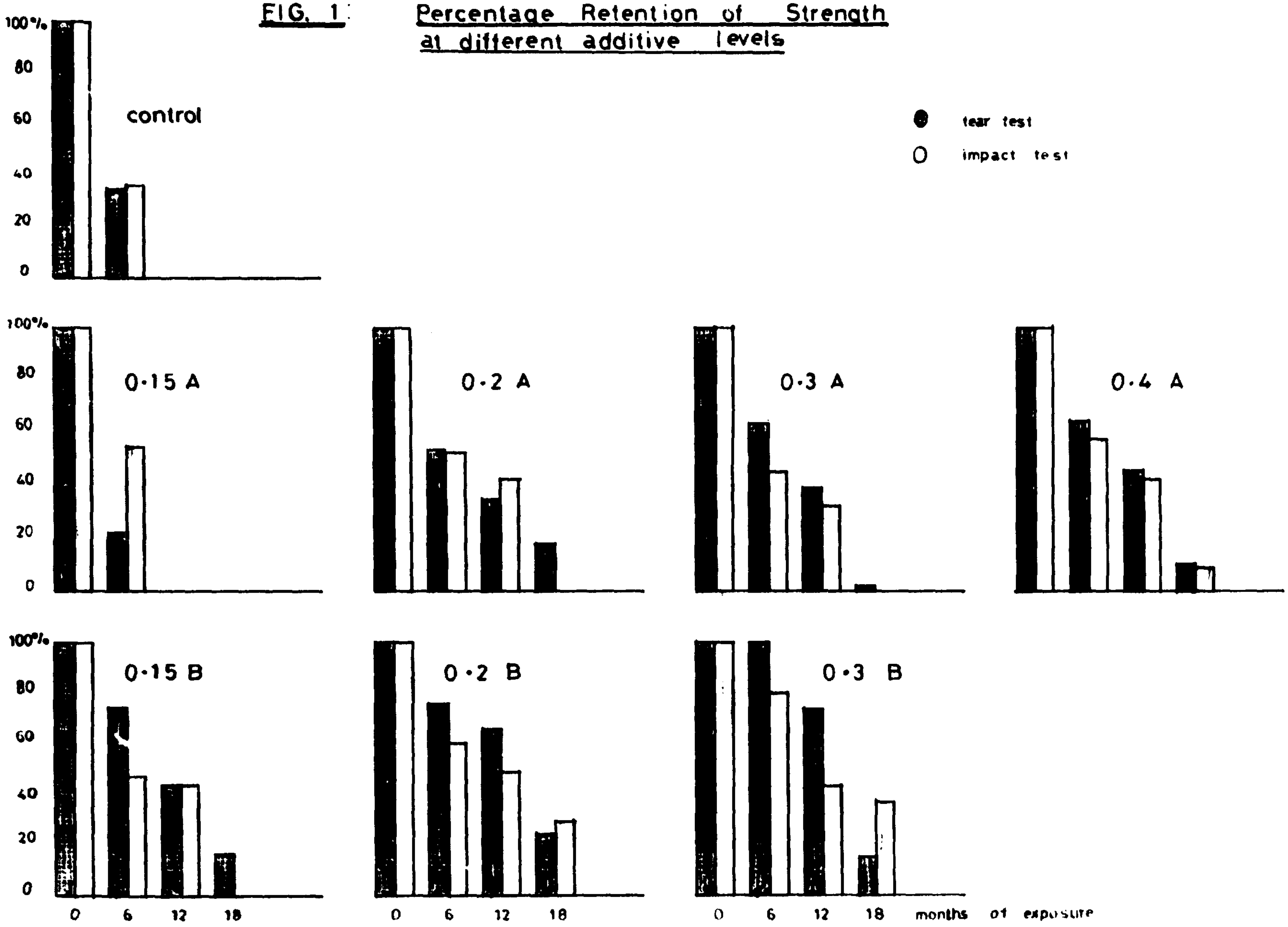
FIG. 1: Percentage Retention of Strength at different additive levels



7. Impact Strength

The impact strength of the samples are detailed in Table No.5, and the percentage retention of original impact strength with time of exposure is detailed in Table No.2

This shows a severe drop for the control film at the six month exposure period but the drop for 0.15A formulation appears no worse than that of four other formulations (0.2A, 0.3A, 0.4A, and 0.15B). Both these two formulations shattered completely in the hailstorm in December 1979, this might suggest that the break-down of the film sample was not uniform, and in turn this could be due to poor dispersion of the low level of additive. In fact, the chemical analysis of the sample supports this proposition.

The percentage retention of impact strength of the A series was within the range 45-50% while for the B series it was within the range 47-80% at the six month exposure period. At the twelve month exposure period these had changed to 32-42% for the A series and 43-49% for the B series. By the eighteen month period the A series had shattered so severely that there remained little of three of these formulation samples. Sufficient for limited test was obtained on 0.4% A which had dropped to 9% and at a level so low that even careful handling of the sample caused it to shatter. On the other hand in additive series B only the 0.15% sample had shattered to leave nothing for testing and the 0.2% and 0.3% additive levels gave a range of 29-37% retention of original impact.

8. Melt flow index

The MFI gives a measure of the viscosity of the polymer at 190°C and this indirectly, gives an indication of the internal structural changes taking place in the polymer due to its exposure to weathering. When the MFI number decreases in size it is indicative of cross-linking taking place within the polymer structure. When the MFI number increases it is

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indicative of polymer scission (breaking of polymer chains). In both cases the elasticity of the polymer can be adversely affected.

The result obtained are tabulated in Table No.3.

The control film shows some tendency to cross linking as does sample 0.15% A before both films shattered in the hailstorm.

On the other hand samples 0.2% A and 0.3% A both show progressive increase of MFI increasing rapidly at the eighteen month period suggesting chain scission is taking place.

The 0.4% A sample on the other hand shows a drop of MFI that is less than 0.05 and indicative of cross-linking throughout the exposure period.

Samples in the B additive series all show a common trend with an initial drop in MFI - indicating cross-linking followed by a **rise** in MFI value indicating chain scission has started. This data can be utilised to aid the interpretation of the tear and impact results. In particular, in evaluating the strength performance of 0.2% B and 0.3% B it is evident that the chain scission of 0.2% B had proceeded much more severely than that of 0.3% B at the eighteen month period. This is reflected in the higher impact figure for 0.3 B and confirming the somewhat better performance of this formulation. The tear strength figures however of both samples are marginal.

d) Accelerated weathering results

Samples of all the formulations were subject to Weather-a-meter accelerated testing through the courtesy of Ciba-Geigy Ltd. These results are set out in Table No. 6.

The percentage retention in elongation at break has been recorded, unfortunately this test could not be undertaken on the samples tested in Cyprus since the tensile strength apparatus, necessary for determining elongation at break, was not then available. Nevertheless some comments can be made.

As with the roof exposure samples the accelerated tests show early failure of the control film (no additive) at 1000 hours and of 0.15A additive at 2500-3000 hours. This better purformance of the 0.15A was not confirmed in the outdoor tests.

The series of A additive show percentage retention of elongation at break in the range of 48-62% at 5,000 hours while for the B additive series the range is only 6-18%. This shows the A additive to be very markedly superior to the B additive.

Unfortunately the outdoor exposed samples show a completely different result in that the B additive is superior in performance to the A additive. While this differnce may be due to the comparison of elongation at break properties experience indicates that there is some correlation with tear and impact properties and the size of the difference of results between these two sets of experiments raises many questions.

The diversity of results is an interesting phenomena, however, due to restricted resources it is not possible to investigate this further. Nevertheless, it is obviously an interesting subject for further research.

Conclusions

1. Although these trials have failed to produce a film of three years life it has nevertheless generated some valuable performance data.

2. Film containing 0.3%* of B additive (1.5% MB 192) has an effective continuous exposure life of greater than 19 months and less than 24 months. It has a life of approximately three time that of film without additive. It should be pointed out that the exposure period covered Summer/Winter/Summer/Winter. This would suggest that film of this formulation could be successfully used for two seasons use, namely Winter/Summer/Winter.

3. Film without additive has a maximum useful life of 7 months, confirming local information that ordinary film has only one season life.

4. All the data gathered, including visual observations, confirm that the B additive system is superior to the A system.

5. A further set of trials, with increased amounts of B type additive, will need to be evaluated to determine a suitable formulation for a three years life film.

* Level of active ingredients.

TABLE NO.1

LONG LIFE FILM TRIALS

PERCENTAGE RETENTION OF TEAR STRENGTH WITH TIME OF EXPOSURE

ADDITIVE IN FILM		PERCENTAGE RETENTION OF TEAR STRENGTH TIME OF WEATHERING IN MONTHS					
%	TYPE	NIL	6	12	18	24	MONTHS
NIL	CONTROL	100	35 TH	-	-	-	
0.15	A	100	22 TH	-	-	-	
0.2	A	100	53	35	18 T		
0.3	A	100	63	59	2 T		
0.4	A	100	64	45	10 T		
0.15	B	100	74	44	16 T		
0.2	B	100	76	65	24	N T	
0.3	B	100	100	74	15	N T	

A) B) ULTRA VIOLET SCREENING ADDITIVES

TH TRIAL TERMINATED ONE WEEK LATER WHEN FILM SHATTERED IN HAILSTORM

T TRIAL TERMINATED - FILM BRITTLE/SHATTERED

N INSUFFICIENT SAMPLE FOR TESTING

TABLE No.2

LONG-LIFE FILM TRIALS

PERCENTAGE RETENTION OF IMPACT STRENGTH WITH TIME OF EXPOSURE

ADDITIVE IN FILM		PERCENTAGE RETENTION OF IMPACT STRENGTH TIME OF WEATHERING - IN MONTHS					
%	TYPE	NIL	6	12	18	24	MONTHS
NIL	CONTROL	100	36 TH	-	-	-	
0.15	A	100	54 TH	-	-	-	
0.2	A	100	52	42	N T		
0.3	A	100	45	32	N T		
0.4	A	100	55	42	9 T		
0.15	B	100	47	44	IS T		
0.2	B	100	60	49	29	N T	
0.3	B	100	80	43	37	N T	

A) B) ULTRA-VIOLET SCREENING ADDITIVES

TH TRIAL TERMINATED ONE WEEK LATER WHEN FILM SHATTERED IN HAILSTORM

T TRIAL TERMINATED - FILM BRITTLE/SHATTERED

N INSUFFICIENT SAMPLE FOR TESTING

TABLE NO. 3

LONG LIFE FILM TRIALS

MELT FLOW INDEX CHANGE WITH TIME OF EXPOSURE

ADDITIVE IN FILM		MELT FLOW INDEX					
		TIME OF WEATHERING IN MONTHS					
%	TYPE	NIL	6	12	18	24	MONTHS
NIL	CONTROL	0.230	0.108 TH	-	-	-	
0.15	A	0.264	0.226 TH	-	-	-	
0.2	A	0.201	0.350	1.86	N T	-	
0.3	A	0.230	0.285	1.69	64.89 T	-	
0.4	A	0.256	NM	NM	NM T	-	
0.15	B	0.282	NM	0.074	26.64 T	-	
0.2	B	0.310	NM	NM	113.4	N T	
0.3	B	0.309	NM	NM	1.49	N T	

A)
B) ULTRA VIOLET SCREENING ADDITIVE

TH TRIAL TERMINATED ONE WEEK LATER WHEN FILM SHATTERED IN HAILSTORM

T TRIAL TERMINATED - FILM BRITTLE/SHATTERED

NM NOT MEASURABLE - LESS THAN 0.05

N. INSUFFICIENT SAMPLE FOR TESTING

TABLE NO.4

LONG LIFE FILM TRIALS

TEAR STRENGTH CHANGE WITH TIME OF EXPOSURE

ADDITIVE IN FILM		TEAR STRENGTH IN GRAMS PER 10 MICRONS					
		TIME OF WEATHERING IN MONTHS					
%	TYPE	NIL	6	12	18	24	MONTHS
NIL	CONTROL	56.5	19.7 TH	-	-	-	
0.15	A	50.4	11.2 TH	-	-	-	
0.2	A	53.7	28.6	18.6	9.7 T	-	
0.3	A	56.0	35.5	33.2	0.9 T	-	
0.4	A	53.3	34.0	23.8	5.9 T	-	
0.15	B	50.9	37.6	22.3	8.0 T	-	
0.2	B	51.3	39.0	33.5	12.5	N T	
0.3	B	49.1	48.9	36.3	7.3	N T	

A } ULTRA-VIOLET SCREENING ADDITIVES
B }

TH TRIAL TERMINATED ONE WEEK LATER WHEN FILM SHATTERED IN HAILSTORM

T TRIAL TERMINATED - FILM BRITTLE/SHATTERED

N INSUFFICIENT SAMPLE FOR TESTING

TABLE NO.5

LONG LIFE FILM TRIALS

IMPACT STRENGTH CHANGE WITH TIME OF EXPOSURE

ADDITIVE IN FILM		IMPACT STRENGTH IN GRAMS PER 200 MICRON THICKNESS TIME OF WEATHERING IN MONTHS					
%	TYPE	NIL	6	12	18	24	MONTHS
NIL	CONTROL	600	356 TH	-	-	-	
0.15	A	788	278 TH	-	-	-	
0.2	A	620	318	274	N T		
0.3	A	844	332	282	N T		
0.4	A	624	340	254	54 T		
0.15	B	710	372	336	N T		
0.2	B	798	418	318	180	N T	
0.3	B	740	722	304	258	N T	

A } ULTRA VIOLET SCREENING ADDITIVE
B }

TH TRIAL TERMINATED ONE WEEK LATER WHEN FILM SHATTERED IN HAILSTORM

T TRIAL TERMINATED - FILM BRITTLE/SHATTERED

N INSUFFICENT SAMPLE FOR TESTING

TABLE NO 6

LONG-LIFE FILM TRIALS

PERCENTAGE RETENTION OF ELONGATION AT BREAK WITH ACCELERATED WEATHERING

ADDITIVE IN FILM		PERCENTAGE RETENTION OF ELONGATION AT BREAK TIME OF ACCELERATED WEATHERING-IN HOURS						
%	TYPE	NIL	250	500	750	1000	1500	HOURS
NIL	CONTROL	100	85	74	14	6	0	
		NIL	1000	1500	2000	2500	3000	HOURS
0.15	A	100	96	102	60	11	3	
		NIL	2000	3000	3500	4000	5000	HOURS
0.2	A	100	104	99	78	74	48	
0.3	A	100	99	96	88	72	62	
0.4	A	100	101	91	81	77	53	
0.15	B	100	100	73	60	33	6	
0.2	B	100	100	97	85	39	6	
0.3	B	100	100	92	107	59	18	

ANNEX B

Extension of the research development programme for long-life film.

Since the trials have indicated that additive B gives improved performance to additive A the extended trials would be limited to formulations based on additive B (Tinuvin MB 192).

As well as exposing the small samples on the special roof unit it was considered that additional practical benefits would be obtained by covering a complete greenhouse with film of each formulation. After discussion it was agreed that covering only the roof area of a greenhouse with each film formulation would be necessary since, in practice, it has been observed that it is the roof area, rather than the sides of the house, which show the first evidence of film deterioration.

Where the film is in contact with a structural member of a greenhouse a 'heat-trap' is formed. The near infra-red solar radiation passes through the film and is absorbed by the structural member. It is then re-radiated by the structural member as long infra-red radiation which is recognisable as heat, and this can develop to an intensity which can degrade the film. This source of degradation to the film can be prevented by painting a white or aluminium coloured paint on top of the film in those areas where it comes in contact with a structural member. An alkyd-based or acrylic oil-based paint can be used for this purpose.

It is proposed that covered greenhouses will be protected by this technique. However, to obtain practical information on the exposure time required to achieve such heat-degradation of the film under Cyprus conditions arrangements will be made for a very small area to be exposed and subjected to regular observation. When embrittlement is noted the area will be suitably patched and protected so that the cropping operations will not be interrupted.

In order to keep the work-load within reasonable bounds, and having regard to the available facilities, it is proposed to restrict the number of formulations to three.

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The choice of concentration of additive has been considered and it is proposed that levels of 0.75%, 1.0% and 1.5% should be used.

The greenhouse to be made available for roof-covering at the ARI Experimental Station at Akhelia are 55 m long and the roof will require a film of 7 ft (2.1 m) width for each side or 4.2 m single width.

Since the rate of ultra-violet radiation degradation increases rapidly towards the end period of the useful life of the film it has been agreed that the sampling frequency will be changed

1st and 2nd year exposure - six monthly intervals

3rd and subsequent year exposure - three monthly intervals.

In order to achieve an improved performance assessment.

It is calculated that 16 square meters of film, in each formulation will fully cover the sample film requirement and leave sufficient in reserve. The number of samples per exposure period will be increased from two to three.

Making allowance for using 2.5 m wide film to cover a greenhouse roof, and providing 2 m of excess length of film at each end it has been calculated that the total film requirement, including the above mentioned sample pieces, will be 311 square meters. In weight terms this approximates to 60 kg per formulation. Assuming 100 kg raw material is prepared to execute each trial then 16 kg of master batch MB 192 will be sufficient to cover all three formulations.

The change in film performance with time of exposure will be monitored by measuring dart impact strength, Elmendorf tear strength, melt flow index as in the original series of trials. Additionally, it will also be possible to measure tensile strength and elongation at break since a suitable test machine is now available.

/NM.