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ID/WG.137/44
18 September 1972

Original: ENGLISH

United Nations Industrial Development Organization

Symposium on the Development of the Plastics Fabrication Industry in Latin America

Bogotá, Colombia, 20 November - 1 December 1972

CURRENT TRENDS IN PLASTICS 1/

prepared by

the Secretariat of UNIDO

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SUMMARY

CURRENT TRENDS IN PLASTICS [1]

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To set the scene for the more detailed contributions from participants dealing with specific topics, the most significant trends of the last decade are reviewed. Overall growth and distribution of plastics production from 1960 are considered and major contributing factors cited. Relative growth rates of polymerization and condensation products in selected countries are used as an indication of world trends. Main technical developments in thermoplastics are enumerated and the most significant trends in the production of the major monomers are discussed. Breakdowns in the consumption of rigid and flexible polyvinyl chloride are listed and probable growth areas indicated. Similar patterns are employed in discussing low and high density polyethylenes, styrene homopolymers, co-polymers and blends. The current situation on polymethyl methacrylate and developments of acrylic co-polymers is outlined. Trends in the thermoplastics field are illustrated by the major developments in the moulding powders, laminates, glass reinforced plastics and polyurethane sectors. The potential role of the developing countries is stressed emphasizing possibilities of UNIDO assistance and the need for innovation.

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C O N T E N T S

INTRODUCTION

1. In attempting to discuss the most significant trends which have occurred throughout the plastics sector during the last decade the necessity to generalise becomes almost inevitable, if only because of the vastness and diversity of the sector and the need to keep within the time limitations imposed.

2. The main objective of this paper is to provide a back-drop, complimentary to Professor Mark's exposition of the sophisticated developments which have occurred in providing us with the materials of tomorrow.

3. The plastics sector may be visualised as a multi-trunked tree, the trunks comprising the major raw-materials, the branches the polymeric materials, the twigs the various processes to which the polymers may be subjected and the leaves the end-use applications. Each stage increasing numerically and in its diversity. In this paper the study embraces primarily the trunks and the main branches, leaving the more complex study of the twigs and leaves to the symposium participants to consider in greater detail.

4. On a geographical basis the essential back-drop is the world but such an essay is fraught with the complexities which inevitably arise from scarcities of information. Thus some of the most significant world trends have to be considered in terms of trends within certain of the developed countries. As most of the participants can speak with authority on Latin American requirements, practices, and more particularly its problems, this paper represents an attempt to "set the scene" as a prelude to the real business of the Symposium.

OVERALL TRENDS

5. World production of plastics has grown from 6.9 million tons in 1960 to 14.5 million tons in 1965 and 30 million tons in 1970, an average compound growth rate of 15.8% per annum. Production distribution is shown in Table I on the following page.

TABLE I

Distribution of Plastics Production

	1960 %	1965 %	1970 %	Growth Rate % per annum
U.S.A.	41.3	36.6	28.2	11.5
Japan	8.0	11.1	17.1	25.1
W. Germany	14.2	13.7	14.4	16.0
Italy	4.4	6.3	5.8	19.1
U.S.S.R.	4.5	5.5	5.6	18.3
France	5.0	4.8	5.0	16.1
U.K.	8.3	6.6	4.9	11.0
Benelux	1.8	2.5	3.7	24.8
Rest of World	12.7	12.9	15.3	18.0

6. Undoubtedly the growth of the plastics industry in Japan has been one of the most significant highlights of the decade. While retaining her position as the world's largest producer of plastics the U.S.A. has inevitably yielded some ground to countries whose industries were less developed initially, particularly Japan, Benelux, Italy and the rest of the world. Of particular significance is the growth of production in Benelux, a situation which has undoubtedly been influenced by the growth of the petrochemicals complexes around Rotterdam and the substantially simultaneous development of Europort. This situation has involved the transfer of manufacture of certain plastics, synthetic fibre polymers and rubbers, by large organizations such as I.C.I., Shell and Dow, into Europe. The development of Europort has also facilitated shipment of products from Rhineland countries.

7. The acceleration of growth of the rest of the world during the latter half of the decade reflects, inter alia, the initiation of plastics production in certain of the developing countries.

8. Further interesting observations can be made by considering the trends in per capita consumption of certain of the developed countries shown in Table II.

TABLE II

Per Capita Consumption of Plastics in Selected Countries

(Kg/head)

	1960	1965	1970	Growth % p.a.
U.S.A.	10.7	24.7	42.0	14.7
Japan	5.9	14.2	42.0	21.7
W. Germany	15.0	26.7	54.0	13.7
Italy	5.0	11.8	26.4	18.1
U.S.S.R.	1.6	—	7.0	15.9
France	7.4	14.1	28.7	14.5
U.K.	9.2	15.1	24.2	10.2
Benelux	8.8	15.3	36.4	15.3

9. W. Germany has retained her position at the head of the table with regard to per capita plastics consumption, probably partly as a result of increased prosperity and because of the greater familiarity with and acceptance of synthetic materials. Italy, Japan and Benelux have experienced rapid increases in consumption while the United Kingdom shows the lowest growth rate in both tables. Her per capita rate may also indicate a degree of conservatism regarding the use of synthetics.

10. If plastics materials are sub-divided into polymerization and condensation products, the growth rate of the former has been consistently higher giving rise to the changes in distribution shown in Table III on the next page.

TABLE III

Polymerization Products vs Condensation Products in Selected Countries

Polymerization Products - A
Condensation Products - B

	Distribution				Growth Rates % p.a.	
	1960		1969			
	A	B	A	B	A	B
U.S.A.	60+	40-	80	20	14	6
Japan	60+	40-	80	20	25	17
W. Germany	49	51	67	33	20	14
Italy	60+	40-	75	25	21	13
U.S.S.R.	15	85	40	60	30	14
France	54	46	—	—	—	—
U.K.	63	37	70	30	11	6
Netherlands	—	—	56	44	40	22

11. The increasing dominance of polymerization products, which consist almost entirely of thermoplastics is clearly shown. Their increasing share of the market in the U.S.S.R. in parallel with other Eastern European socialist countries, which at the begining of the decade the production of condensation products clearly dominated, can soon be expected to reach parity.

12. While both classes of plastics continue to encroach upon traditional materials in addition to creating new applications encroachment of thermoplastics on the use of thermosetting condensation products has been most marked in the field of consumer durables. In such fields as industrial binders, adhesives and surface coatings the thermosets can be expected to hold their own.

13. While at the begining of the decade the United States was the leading exporter by 1969 the Federal Republic of Germany had not only taken over this position but was exporting almost twice as much, the Netherlands had taken over the second position and the United Kingdom had been overtaken by Italy. Of the countries in Western Europe Germany, Benelux, Italy and United Kingdom maintained a favourable balance of exports over imports of plastics with France and Norway, having balanced exports and imports

THERMOPLASTICS

14. The last decade has seen the successful commercialization of a wide range of new thermoplastics which have embodied significant improvements in major characteristics including heat resistance, clarity and strength combinations and processability. These include:

TABLE IV

Newer Thermoplastics

Product	Company	Major Property Contribution
Polycarbonates	Bayer	Clarity, toughness pro-rata to heat resistance.
Polyacetals (Polyoxymethylenes)	Du Pont, Celanese	Toughness, solvent and hot water resistance.
Polyphenylene oxides	C.E.C.-A.K.U.	Heat resistance
Polysulphones	Union Carbide	Heat resistance
TPX (poly-4-methylpentene-1)	I.C.I.	Clarity - low density-heat resistance.
Polybutene-1	Mobil Hüls	Clarity - low density-heat resistance.
Isotactic polyisobutene	Petro Tex.	Strength-flexibility-creep resistance.
Aromatic polyamides	Du Pont	Heat resistance
Poly-p-xylenes		Heat resistance
Polyimides (poly-pyromellitimides)	N.P.L., Du Pont Westinghouse	Outstanding heat resistance

15. In addition the range of co-polymers based upon well-established monomers has been extended commercially by exploitation of more sophisticated polymerization techniques, to result in, among other products, improved grades of high impact polystyrene, ABS, MBS and SAN co-polymers. These developments, in particular, have been of major significance to thermoplastics fabricators. In the surface coatings and adhesives fields the commercial development of a wide range of acrylic and substituted acrylic binary and ternary co-polymers, tailored to fulfill such specific functions as flexibility, water solubility and cross-linkability have made a great impact on the finishing field and facilitated the development of, for example, electrophoretic coating.

16. The major growth in production has, however, taken place with respect to the well-established polymers and both the recent short-term future capacity trends will be considered. Perhaps, however trends and predictions can best be put into perspective initially by considering monomer production.

Monomer Production

17. Not only is ethylene the basic raw-material for the polyethylenes but; particularly since the controversy on the economics of production of vinyl chloride appears to have been resolved; also it has become the most economic intermediate for vinyl chloride production. It is also basic to the manufacture of both styrene and vinyl acetate. Its consumption distribution in Western Europe and the United States is shown in Table V.

TABLE V

Consumption Distribution of Ethylene (1970)

1980 forecasts in parenthesis

	W. Europe %	U.S.A. %	Intermediate for:
Low Density Polyethylene	39	38 (29)	-
High Density Polyethylene	12		-
Vinyl chloride	15	13 (13)	PVC and VC co-polymers
Ethyl benzene	8	10 (9.5)	Styrene
Ethylene oxide	16	21 (16)	Ethylene glycol (Polyester
Ethyl alcohol	4	10 (4.5)	general
Acetaldehyde	4	— (4.5)	general
Others	2	8 (9.5)	Incl. Vinyl acetate
Total	100	100	

18. From 1961 to 1970 world consumption of ethylene increased from 3.8 million tons to 17 million tons, with average plant capacities increasing from approximately 50,000 tons per annum to between 150,000 and 500,000 tons per annum. Thus economies of scale are playing a progressively more vital role in planning.

19. Allied to this growth the establishment of pipe lines in Western Europe has become well advanced, having been preceeded by those in the United States, particularly in Texas. In addition to pipeline development of refrigerated

tankers for sea transport and improved terminal facilities for reception, storage and distribution greatly improved tracing facilities during the decade.

20. The steam cracking of naphtha has assumed increasing importance for the production of ethylene. In this process propylene is an inevitable co-product but improvements in control of the severity of the operation have lead to greater predictability of the balance of the two products.

21. In parallel with ethylene, propylene is of considerable importance in the plastics field and, as the consumption distribution figures shown in Table VI show, not only for the production of polypropylene but also as an intermediate for many plastics raw-materials.

TABLE VI

Consumption Distribution of Propylene (1970)

	W. Europe	U.S.A.	
Polypropylene	13.2 (21)	13 (28)	
Acrylonitrile	15.8 (28)	18 (13)	Fibres, elastomers, ABS, SAN
Cumene	11.9 (10)	7 (8)	Phenol - synthetic resins
Isopropanol	13.9 (10)	21 (13)	Solvent, esters, etc.
Plasticiser alcohols	21.0 (19)	- (11)	Phthalate esters, etc.
Propylene Oxide	12.3 (12)	11 (13)	Propylene and polypropylene glycols - polyurethanes.
Other	20.0 -	25 (14)	Inc. butyraldehyde, methyl pentene, etc.
Total	100.0	100	

22. Although the distributions of usage of both ethylene and propylene vary from country to country in both cases the proportions employed for polymers and polymer intermediates has increased significantly throughout the decade and by 1980 it is forecast that the trend should continue with probable distributions shown in parenthesis in Tables V and VI.

23. In 1969 world ethylene capacity reached 22 million tons which was distributed approximately as follows: U.S.A. 45%, Western Europe 23%, Japan 12%, U.S.S.R. 5% and other countries 15%. The capacity for propylene in Western Europe, U.S.A. and Japan was 9 million tons, that for the remainder of the world being unknown. It is anticipated that by 1980 the output of ethylene will reach 44 million tons in Western Europe, U.S.A. and Japan alone. Confirmation of the realistic

nature of expansions in both monomer and polymer production will be appreciated by examination of the analysis of plant contracts in Appendixes I and II.

24. Whereas at the begining of the decade the relative economics of producing vinyl chloride from acetylene or ethylene via the ethylenedichloride route were being hotly debated and by 1965 processes were being based upon balanced units involving both feedstocks, the development of the process based upon the oxychlorination of ethylene, to eliminate by-product HCl, has settled the controversy and this process is rapidly being established over a wide scale.

25. The production of vinyl chloride is almost inevitablyllinked to its polymerization either on site or over-the-fence. Production capacities for the polymer throughout the world had reached an order of 7 million tons by 1970, the distribution being shown in Table VII.

TABLE VII

PVC Plant Capacities (1970)

tons x 1,000 (t.p.a.)

	Overall	Average Unit Size
E.E.C.	2,000	62
E.F.T.A.	580	—
Socialist Block	702	—
U.S.A.	2,120	—
Japan	1,480	—
Latin America	156	13
Continental Africa	38	19
Total	7,076	

26. The size of both monomer and polymer plants,in all the industrialized countries has increased significantly the minimum economic scale of which had reached 25,000 tons per annum for polymer and 60,000 for monomer by 1970.

27. In this context, however a recent feasibility study, carried out by a UNIDO expert, demonstrated that the manufacture of vinyl chloride by the Kaheda/Chiyoda process could be viable for certain developing countries at capacities as low as 12,000 tons per annum. This process is based upon an integrated unit for steam cracking naphtha to yield mainly ethylene and acetylene in the form of [illegible] feed-stock. Also a most interesting comparison has been made on the

basis of 20,000 tons per annum plants in remote locations, by Mr. P.C. Candle of the Planning Department of B.P. Chemicals, of the various routes to vinyl chloride monomer.

TABLE VIII

Process Selection of Vinyl Chloride Routes

Process	Feed-Stock and Price (cts/lb.)	Comparative VCM Cost (cts/lb.)
Oxychlorination	Ethylene - 7	8.7
Deacon Process (HCl utilised)	Ethylene - 7	8.6
Deacon (HCl to waste)	Ethylene - 7	9.2
Dilute oxychlorination	Naphtha - 0.95	8.7
Balanced Process	Ethylene - 7 Acetylene - 14	9.2
Acetylene	Acetylene - 14	10.0
Kureha/Chiyoda	Naphtha - 0.95	8.1

28. Technically the development of hyperchlorinated PVC and the St. Gobain process for bulk polymerization have been of major significance in polymer manufacture.

Polyvinyl chloride

29. With the progressive improvements in fabrication techniques, the growth of applications for rigid PVC has increased and in the European Common Market countries by 1970 its consumption had almost equalled that of flexible PVC, the distribution of both types being shown in Table IX.

TABLE IX.

Breakdown of PVC Consumption E.E.C. Countries %

Rigid PVC		Flexible PVC	
Foils and films	9.8	Cables	9.7
Sheets	3.2	Foils and films	10.5
Pipes and profiles	24.6	Flooring	9.7
Bottles	3.2	Pipes and profiles	6.0
Other applications	8.2	Other applications	15.1
Total	49.0	Total	51.0

30. It is anticipated that the balance of use between rigid and flexible will progressively move towards a situation whereby the rigid material will represent about 60% of the total.

31. Major growth areas for PVC are expected to include rigid and semi-rigid films for packaging, leathercloth for upholstery provided that it remains cheaper than polyurethanes, and rigid pipes and profiles for the building and other industries. While the encroachment of rigid PVC on the use of glass for bottles has been successful, in the high volume market as represented by milk bottles high and medium density polyethylene are likely to prove more successful. It is anticipated that such well-established applications as floor tiles and injection moulded articles have reached a near stable position and will not continue to expand at as high a rate as the other applications.

32. It is anticipated that by 1975 Japan will have the highest per capita consumption of PVC at 15.5 kg/head with the E.E.C. countries second at 14.8 kg/head followed by the U.S.A. at 9.7 kg/head.

33. Because of its longer history the growth rate in the consumption of PVC has not been as high as the more recent polyolefines but nevertheless, according to the Stanford Research Institute, world consumption is expected to have an annual growth rate of 11% to 1980 which is in line with the expected growth rate of plastics overall of 11-12% per annum.

Polyolefines

34. Comprising low density polyethylene, high density polyethylene, polypropylene, polytetrafluorethylene, and more recently poly-4-methylpentene-1 and polybutene-1 the polyolefines have shown the greatest increase in consumption and diversification over the decade. On a world basis the major polymers of this group represented 27% of total plastics consumption and this proportion is expected to increase to 30% by 1975 and 33.5% by 1980.

35. Whereas in 1960 low density polyethylene represented some 80% of polyolefines consumption, by 1970 the proportions were:

LD Polyethylene	61%
HD Polyethylene	21%
Polypropylene	16%
Others	2%

36. On a per country basis the proportion of LD polyethylene remained fairly

uniform the balance between HD polyethylene and polypropylene varied, for example, between W. Germany where consumption of the former was very much higher than the latter to countries such as the United Kingdom where a higher proportion of polypropylene was consumed.

37. World plant capacity for polyolefines increased dramatically during the decade with plants for the manufacture of LD polyethylene being established throughout the world and the commencement of manufacture of polypropylene (1963) in Western Europe. By 1970 the production of polyethylene had outstripped that of PVC in Japan, the U.S.A. and the U.K.

38. Some idea of the consumption breakdowns of the major polyolefines can be obtained by comparison of those for the U.S.A. and the U.K. in Tables X, XI and XII.

TABLE X

Consumption Distribution of Low Density Polyethylene (%)

	1964		1968		1971	
	U.S.A.	U.K.	U.S.A.	U.K.	U.S.A.	U.K.
Film sheet	44.9	41.8	47.1	53.3	56.1	57.3
Injection moulding	20.4	24.9	16.1	16.9	14.3	14.4
Blow moulding	2.9	11.0	1.9	10.2	1.4	9.6
Wires and cables	11.5	9.4	13.2	10.2	10.4	7.9
Extrusion coating	13.8	5.1	12.6	5.2	9.1	4.5
Pipes, etc.	3.8	4.5	2.7	2.6	1.7	2.1
Other	2.7	3.3	6.4	1.6	8.5	4.2
Consumption(tons x 1,000)					1,940.0	291.0

39. The trend in demand for low density polyethylene film has been such, that throughout the industrialised countries it now exceeds 50% of all usage. In Japan it now approximates to 60%. Injection mouldings are tending more towards the other polyolefines and in blow moulding high density polyethylene has gained more popularity both in the unblended state and blended with the low density polymer to achieve better rigidity. Some ground has been lost to PVC in the manufacture of pipes.

TABLE XI

Consumption Distribution of High Density Polyethylene (%)

	1968		1971	
	U.S.A.	U.K.	U.S.A.	U.K.
Film and sheet	5.0	4.0	5.6	7.6
Injection moulding	24.7	32.0	26.2	28.6
Blow moulding	48.4	48.0	50.8	52.2
Wires and cables	4.1	..0	2.2	1.3
Extrusion coating	1.1	-	1.9	-
Pipes, etc.	6.4	4.0	7.1	3.4
Fibre (Monofilament)	0.5	4.0	0.6	3.7
Rotational moulding	13.7	-	2.2	-
Miscellaneous	8.2	4.0	3.4	3.2
Consumption (tons x 1,000)	490.0	46.0	722.0	59.5

TABLE XII

Production Distribution of Polypropylene (%)

	1968		1969	1971	
	U.S.A.	U.K.	U.S.A.	U.S.A.	U.K.
Injection moulding	51.8	52.0	54.1	n.a.	45.4
Blow moulding	1.6		1.3	n.a.	
Fibres	28.0	29.5	29.1	n.a.	27.4
Film		14.5		n.a.	13.1
Pipe and extrusions	10.0	3.0	9.7	n.a.	12.3
Sheet				n.a.	
Film				n.a.	
Miscellaneous	6.8	1.0	4.3	n.a.	1.8
Consumption (tons x 1,000)	356.0	57.0	412.0	482.0	110.0

40. Although figures for consumption distribution of polypropylene by fabrication process have not been available from the United States since 1970 the current form in which they are presented gives an interesting distribution between markets as is shown in Table XIII.

TABLE XIII

Market Distribution of Polypropylene (U.S.A.)

	1971 (%)	
Appliances	6.4	Major and small including radio and TV.
Building	1.8	Pipe conduit and other including fittings.
Electrical	1.7	Wire cable and others
Furniture and Domestic	7.8	Furniture and housewares
Fibre Products	32.0	Including filaments
Travel goods	1.2	Luggage and cases
Medical	3.2	—
Packaging	19.0	Ranging from bottles and closures to film and containers.
Toys and novelties	4.4	—
Transportation	14.8	Including battery cases
Miscellaneous	7.7	

Styrene Polymers and Co-Polymers

41. Polystyrene, which was developed commercially during the late 30's, has, by comparison with the other major thermoplastics, become relatively static. Its derived products, particularly high impact grades which were developed during the 1950's and its co-polymers, ABS, SAN and, to a lesser extent, MBS have continued to increase their popularity during the 1960's and, in parallel, expandable grades have found extensive use during this period. This situation is illustrated by their production in the U.K., where a plant for producing ABS was introduced during 1962, is shown in Table XIV.

TABLE XIV

U.K. Production of Polystyrene and Related Plastics

Production	1963	1965	1967	1969	1971
(tons x 1,000)	77.5	93.5	118	174	199
%	100	122	153	225	257
Homopolymer %	42.7	31.0	29.9	27.9	25.6
Toughened grades %	43.8	46.0	46.5	49.7	46.4
Expandable grades %	7.1	11.5	13.9	13.8	13.7
ABS %	6.4	11.5	10.7	8.6	14.3

42. A capacity increase for ABS occurred during 1969/70 and a capacity increase for expanded polystyrene is scheduled for 1972. It should be noted that the figures for expanded polystyrene do not include extruded foamed sheet produced from non-expandable pellets.

43. The growth of SAN has not achieved expectations and its demand in both the United Kingdom and the United States is still less than that of ABS.

44. With a market for styrene polymers and co-polymers approaching 13/4 million tons, largely catered for by indigenous production, the United States maintains its position as the World's largest producer, followed by Japan and Italy both of whom have experienced a rapid expansion during the latter half of the decade.

45. While with the various grades of polystyrene there have been no significant changes in their pattern of consumption, ABS has enjoyed rapid expansion into the automotive field, with such items as fascias, crash pad housings trims and radiator grills, the consumer durables field with thermoformed refrigerator linings, etc. and encroachment on the use of polymethyl methacrylate in telephone hand sets.

Acrylics

46. Like polystyrene, polymethyl methacrylate was established during the 1930's but, being a relatively expensive polymer, it has not attained such high bulk production. With the popularisation of extruded sheet during the early 1960's, particularly in Italy, cast sheet suffered some set-back but retained its position with respect to the more technically demanding applications in such fields as glazing. lighting and exterior signs. Biaxially oriented cast sheet was developed for aircraft glazing and, for specialized applications for interior usage, fire retardant grades were successfully commercialized. Moulding powders have successfully maintained their position for automotive lighting lenses but have suffered declines in other fields by replacement by styrene co-polymers.

47. In the surface coatings field the commercialization of acrylic and methacrylic co-polymers in emulsion and solution forms has made considerable impact, particularly in the automotive field. In this context the capacity to tailor into the co-polymer specific types of functionality, such as cross-linkability, inherent flexibility and water solubility have proved invaluable.

48. In the fields in which their use has been established, potentials are by no means exhausted. In the developing countries the use of [illegible] sheet has proven of particular interest and UNIDO has issued a report on its manufacture[1].

THERMOSETS

49. Because of the mainly batchwise nature of the production methods employed in the manufacture of most thermosetting resins their production is distributed between a much larger number of producers, many of whom are quite small, throughout the world. Although they must clearly be included in the definition of plastics among many of their diverse applications are those which are not regarded, at least by the lay public, as being associated with plastics. Those fields include particularly adhesives, surface coatings and industrial binders. In consequence of these factors it is proposed only to make a non-quantitative appraisal of major trends emphasising, where possible, those aspects most likely to have some relevance to developing countries.

50. With the exception of the unsaturated polyesters, polyurethanes and epoxides, all of which have been developed since 1945, the major thermosets have grown at a considerably slower rate than the thermoplastics, particularly during the last decade.

Moulding compounds

51. Despite the encroachment of improved thermoplastics, and probably partly due to the development of injection moulding techniques, thermosetting moulding powders have been able to achieve some growth. Improvements in their production, particularly in the development of continuous manufacturing methods, based upon extruder-mixers, have been a significant feature of the last decade. In the case of the phenolics this has been facilitated by the development of novolaks possessing a combination of fast cure with high flow characteristics. Melamine moulding powders have continued to maintain their hold on the production of dinnerware in both the United States and the United Kingdom, while the ureas continue to find electrical applications and closures as their major outlets. The applications for phenolic moulding powders are more diverse than those of the aminoplasts and they continue to find major outlets in the automotive, electrical, appliance and communications fields.

1/ "Guidelines for the production and marketing of [illegible] in developing countries" - Petrochemical Industry Series No. [illegible] United Nations Publication - Sales No. E.[illegible] (ID/SER.J/6).

Laminates

52. The demand for decorative laminates, based upon melamine faced phenolic papers, particularly from the furniture and kitchen fitments sectors, although well established at the begining of the decade, has intensified and, in combination with particle board, decorative laminates with wood grain finishes dominate the lower-priced end of the furniture market. Laminating plants have become established throughout the world, particularly in those countries with large indigenous pulp-wood industries. The size of laminating presses increased over the last five years from 8 ft. x 4 ft. to up to 10 ft. x 6 ft.

Glass reinforced plastics

53. The 1950's were marked by intensive developments in the formulation of specially tailored unsaturated polyester resins to meet such requirements as fire-retardance, water and chemical resistance and non-air inhibition also parallel developments in glass fibre treatments to promote primary adhesion with the cured resin. The last decade has seen more activity in the development of both larger and more diversified structures and the general acceptance of GRP insuch traditional fields as marine construction. As an indicator of their growth, sales of unsaturated polyester resins increased from approximately 9.5 thousand tons in 1960 to 42.5 thousand tons in 1970 in the United Kingdom.

54. Although GRP structures based upon epoxide resins continue to have specialised application this only represents about 5% of their total application and less than 1% of total resin usage in GRP, an alteration in this situation cannot be foreseen.

Polyurethanes

55. Of all the thermosetting resins undoubtedly the polyurethanes have shown the highest growth rate over the decade, despite limitations in the supply of diisocyanate on occasions. Their largest outlet has been as flexible foams, which are now based almost entirely on polyethers. Marked interest has developed in the use of rigid foams for insulation and particularly integrally skinned cast rigid foams for structural applications in which very precise simulations of carved timber have been achieved. Consumption of flexible foam alone in the United States, West Germany and the United Kingdom reached an order of 400 thousand tons in 1971. In the United States of America the consumption of rigid foam of 320 thousand tons was slightly in excess of foamed polystyrene.

CONCLUSIONS

56. It can be clearly seen that in the future world-wide exploitation of the benefits to be obtained from plastics, not only as alternatives to diminishing natural products but also in the creation of new potentials, the role of the developing countries is as vital as that of the developed countries.

57. An additional illustration of this factor is that as countries progress in industrialization their conciousness of the need for and their capability of contributing to new technical developments becomes enhanced. This is clearly shown by events occuring in Israel and Romania. The IMI Institute for Research and Development of Israel have initiated a range of terpolymers based upon vinyl chloride and propylene and chlorinated polyethylene and are actively engaged in developing these processes to commercial scale. In Romania a joint centre, created by the Government and UNIDO, for co-operation in the chemical and petrochemical industries for the benefit of the developing countries, came into being on May 12 this year.

58. Finally it cannot be overemphasised that there is no monopoly either of brain power or the capacity to innovate. Development arising out of innovation can prove an expensive business and it is in this sphere that UNIDO assistance can prove of major benefit.

APPENDIX I

EXPANSION OF MONOMER PRODUCTION CAPACITY

Contractors Plant Additions and Expansions 1970/73 - tons per annum x 1,000

EUROPE

Scheduled Completions		1969/70	1970/71	1971/72	1972/73
Belgium:	Ethylene	250 exp.			
	Propylene	-			
	Viryl chloride			200	
Czechoslovakia:	Ethylene			79 in hand	
	Vinyl chloride		100		
East Germany:	Ethylene				300 due 1973
Finland:	Vinyl chloride				?
France:	Ethylene		320	400	600 due 1973
Hungary:	Ethylene				200 planned
	Propylene				125 planned
	Vinyl chloride				36
Italy:	thylene	260 exp.		500	
	Styrene			225	
Netherlands:	Ethylene	400 + 300		DSM ? 400	450 in hand
	Propylene			DSM ? 200	
	Vinyl chloride		300	300	
	Styrene		214		
Poland:	Ethylene			74	
	Propylene			52.5	
Romania:	Ethylene				220 in hand
	Vinyl chloride		36		
Spain:	Ethylene	260			120
	Vinyl chloride		150	200	30
	Styrene				
Sweden:	Ethylene	250			?
	Acrylics				

Europe cont'd		1972 Ca	1973 Ca	1974 Ca	1975 Ca
Turkey:	Ethylene		30		
	Vinyl chloride		20		
	Styrene			25	
United Kingdom:	Ethylene			340	due 450
	Propylene			200	due 300
	Vinyl chloride			260	exp. of oxy chlor proc. to 450 by 1975
	Acrylates (Me and Et.)		72		
U.S.S.R.:	Ethylene			450 in hand	
West Germany:	Ethylene		360		200 + 400 due 197?
	Propylene	85	265		130
	Vinyl chloride		85		
Yugoslavia:	Vinyl chloride				10 due 1974
LATIN AMERICA					
Antilles:	Ethylene				
	Propylene			150	
	Vinyl chloride (via ethylene)			500	
Argentina:	Ethylene	15		76	120 + 45 exp.
	Vinyl chloride				?
	Vinyl acetate				15
Brasil:	Ethylene				?
	Vinyl chloride			100	?
	Styrene			60	
Chile:	Vinyl chloride	16	18.2	18.2	
Mexico:	Propylene				110
	Vinyl chloride				55
Puerto Rico:	Ethylene			500	500
	Propylene			300	
Venezuela:	Ethylene				95
	Propylene				150

MIDDLE AND FAR EAST AND OCEANIA		1969/70	1970/71	1971/72	1972/73
Australia:	Ethylene		100		
	Styrene			? exp.	
	Vinyl acetate		12		
India:	Ethylene)				
	Propylene)			80	
	Styrene	10			
Japan:	Ethylene	300	300		
	Vinyl chloride		120		
	Vinyl acetate	75			
South Africa:	Ethylene	110			
South Korea:	Ethylene			150 (+butadiene)	
	Vinyl chloride				60
Taiwan:	Vinyl chloride			60	
Thailand:	Vinyl chloride			? exp.	

OTHERS

Canada:	Ethylene				80 (exp. from 100)

APPENDIX II

EXPANSION IN POLYMER PRODUCTION

Contractors Plant Additions and Expansions 1970/73 - tons per annum x 1,000

EUROPE

Scheduled Completions		1969/70	1970/71	1971/72	1972/73
Belgium:	LD Polyethylene		50	50	
	Polystyrene			45	
Bulgaria:	LD Polyethylene		24		
	Polystyrene		12		
Czechoslovakia:	LD Polyethylene			? exp.	
	Polypropylene		30		
	Polystyrene		42		
	ABS		8		
East Germany:	HD Polyethylene			?	
Finland:	Polyvinyl chloride				?
	Polystyrene				20
France:	LD Polyethylene	60		30	60
	Polypropylene		100	7	
	HD Polyethylene			27	
Hungary:	LD Polyethylene		24		
	Polyvinyl chloride			27	
Italy:	HD Polyethylene			10	
Netherlands:	LD Polyethylene	60			
	Polystyrene, etc.			Noryl	
	Polyvinyl chloride			110	
Poland:	LD Polyethylene			30	
	Polystyrene			10	(ABS and SAN?)
Romania:	LD Polyethylene		60		
	HD Polyethylene				
	Polystyrene				30
	Polyvinyl chloride		16		?

Europe cont'd		1969/70	1970/71	1971/72	1972/73
Spain:	Polyvinyl chloride				?
	Polystyrene				?
Sweden:	HD Polyethylene		32		
	Polyvinyl chloride		25	20	
Turkey:	LD Polyethylene			15	
	Polystyrene				15
	Polyvinyl chloride				13 exp.
United Kingdom:	LD Polyethylene			54	
	Polypropylene			90	
	Polystyrene, etc.		20 HI PS.		Styrocell
U.S.S.R.:	LD Polyethylene			exp.	
Yugoslavia:	LD Polyethylene				60(planned '74)
	HD Polyethylene				60(planned '74)
	Polyvinyl chloride				40(planned '74)

LATIN AMERICA

Antilles:	Polyvinyl chloride				?
Argentina:	HD Polyethylene				?
	Polyvinyl chloride				?
Brazil:	LD Polyethylene		75		
	HD Polyethylene				12
	Polyvinyl chloride			40	25
Chile:	LD Polyethylene	15		20	20
	Polyvinyl chloride	15			15 (150)
Mexico:	LD Polyethylene		51 exp.		
Puerto Rico:	LD Polyethylene			135	

MIDDLE AND FAR EAST AND OCEANIA		1969/70	1970/71	1971/72	1972/73
Algeria:	HD Polyethylene				48
Australia:	LD Polyethylene				24 exp.
	HD Polyethylene				?
	Polypropylene			25	
	ABS		5		
India:	Polyvinyl chloride			16	
Indonesia:	Polypropylene				20
Iraq:	Polyvinyl chloride				30 (planned)
Japan:	LD Polyethylene			30	
North Korea:	LD Polyethylene				25
South Korea:	LD Polyethylene			50	
Thailand:	Polyvinyl chloride	?			

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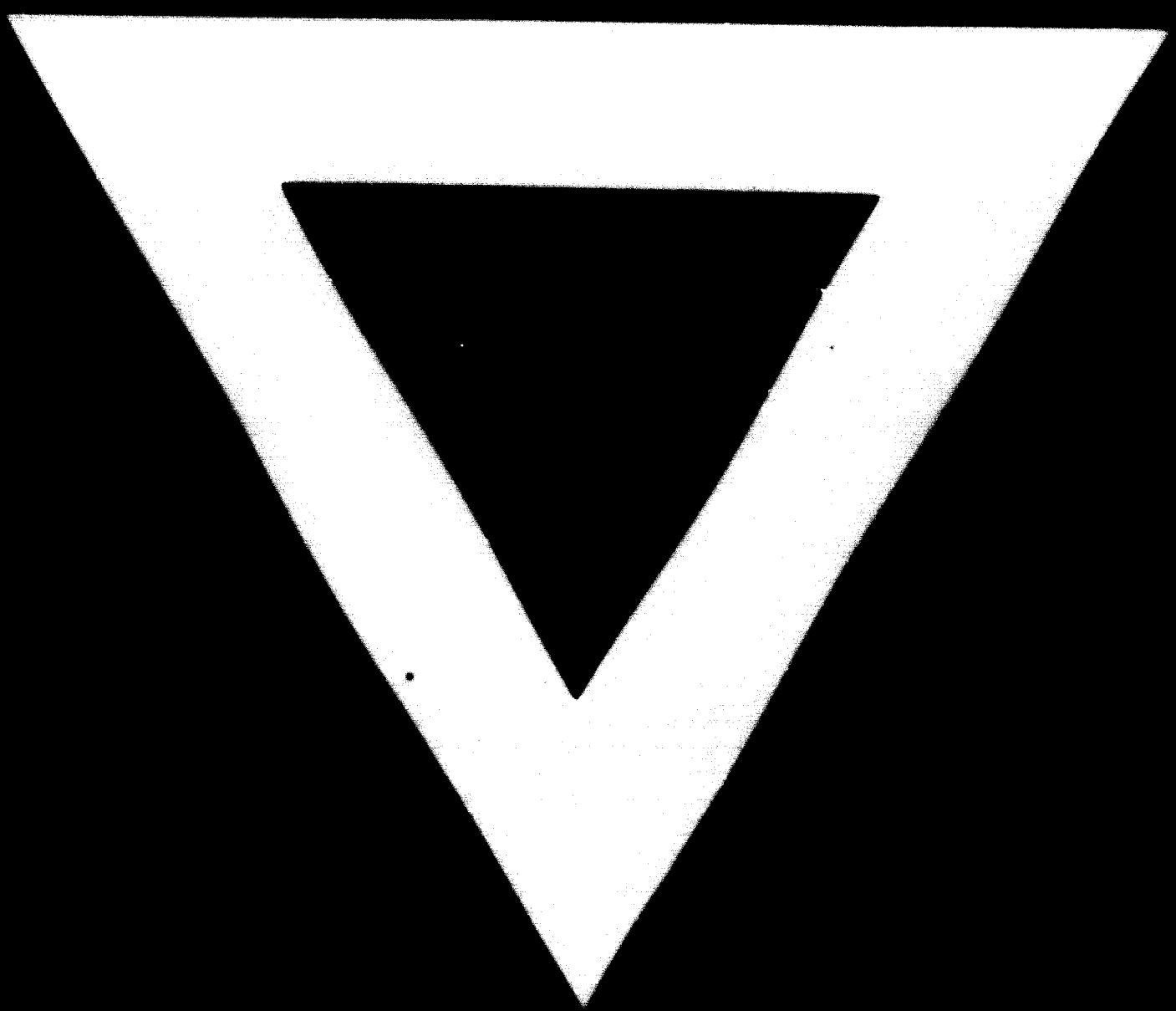

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