

Future Trends in Polymer Science and Technology

Polymers: Commodities or Specialties?

Edited by:

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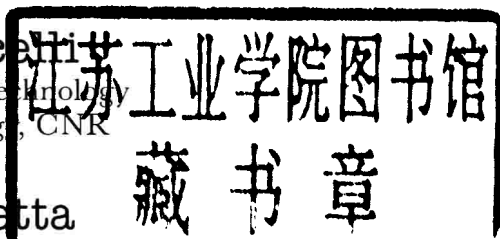
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Future Trends in Polymer Science and Technology

PREFACE

The International workshop on "Future Trends in Polymer Science and Technology Polymers: Commodities or Specialties?" assumed a very important role insofar as it helped identify current research and future trends in the field of polymer science and technology. Interesting comparisons can thus be made among international trends. These will emerge during the course of the lectures presented at the Conference by qualified scientists and managers from a variety of sectors. The question is posed: Who should produce "commodity" polymers and who should produce "specialties?"

Obviously the groups which have access to the basic raw materials and possess the capacity to make substantial investments will produce large-scale commodity polymers. However, in so doing they will have many opportunities to add specialties to their product line. "Specialty polymers" is not a very clearly defined term. Generally, it is associated with high-price, low-volume materials possessing exceptional properties. The word "specialty" refers not only to products but also to processes.

Regarding the development of the polymeric materials industries, all conclude that the growing use of specialty polymers and their modified compounds as structural replacements for metals in the automotive, aerospace and construction industries, will stimulate demand for these products at a rapid rate in the next several years.

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Achievements of the "Finalized Project on Fine Chemistry" in the Sector of Polymer Chemistry: University-Industry Research Relationships

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INTRODUCTION

The present conference "Future Trends in Polymer Science and Technology; Polymers: Commodities or Specialties?" is taking place almost a year before the termination of the Finalized Project on Fine Chemistry (FPFC) of the CNR in which the sub-project Polymeric Materials (SPC) operates. (FPFC started in July 1980 and will officially stop operating halfway through 1985.)

Meanwhile this Conference undertakes a very important role insofar as it contributes to identifying current research and future trends in the field of the science and technology of polymers. Furthermore it gives us the opportunity of discussing the actual status of the research programmes sponsored by the FPFC in the polymeric materials field. Interesting comparisons may therefore be made with international trends, which will emerge during the course of the lectures presented here.

These comparisons will, I hope, lead to suggestions useful for the identification of the most important research lines to be jointly pursued by both academic and industrial groups, in the framework of organizing a second FPFC.

For the attainment of these objectives it is useful to remember the reasons which have led to the organization (within the FPFC) of research activities in the polymeric material sector, the type of articulation and researches activated, as well as the national industrial context in which they are framed.

1) Characteristics of the Italian Polymeric Material Industry and Future Prospects of Development in an International Competitive Context

The sector of polymeric materials (including plastics, elastomers and fibers) represents about 20% of the turnover of the overall Italian chemical industry (see Figure 1).

In this sector Italy holds one of the first places as far as world classifications of production volumes are concerned. Notwithstanding this fact, the sector is characterized by a large presence of foreign companies and this underscores the fact that Italian companies are unable to satisfy the large consumer demand on the home market (see Figures 2 and

**COMPOSIZIONE % DELLA CIFRA D'AFFARI
DELL'INDUSTRIA CHIMICA NEL 1983**

**BREAKDOWN OF SALES ACCORDING TO MAJOR
SECTORS OF ACTIVITY AS A PERCENTAGE OF
TOTAL SALES IN 1983**

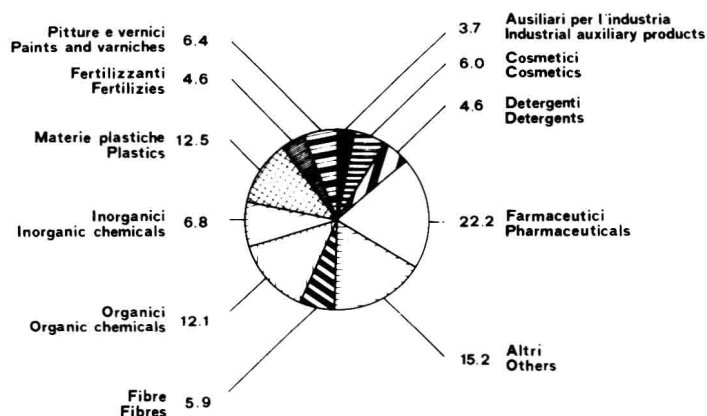


Figure 1. Breakdown of sales of Italian chemistry industry according to major sectors of activity as percentage of total sales in 1983.

3) and by an overall balance of payments which was nearly always negative during 1979 – 1983 (see Figures 4a through c).

The production of polymeric materials in Italian industry is disproportionately weighted to “commodity” or “bulk” plastics and penalizes special polymers (see Figure 5). The latter consideration applies to the whole national chemical sector as illustrated in Figure 6 where the production mix between commodities and specialities of Montedison is compared with that of some worldwide chemical industries.

Halfway through the 70's the European plastic material industry (Italy included) went through the heaviest crisis it had ever known. The extrapolation of early 1970 data for

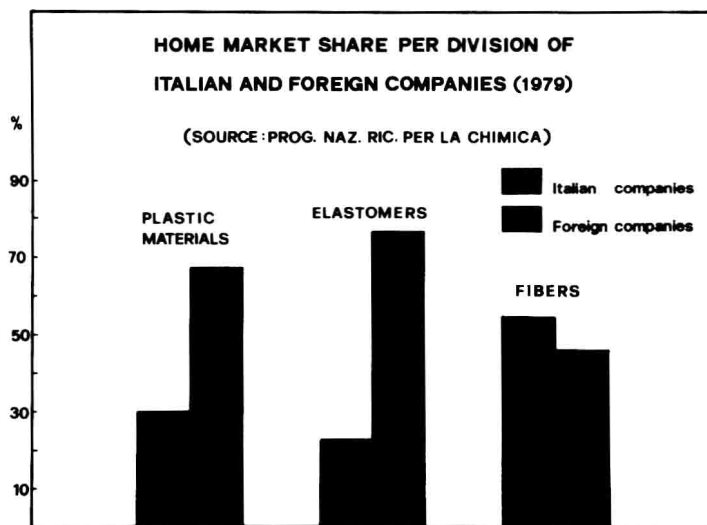


Figure 2. Home market share per division of Italian and foreign companies (1979).

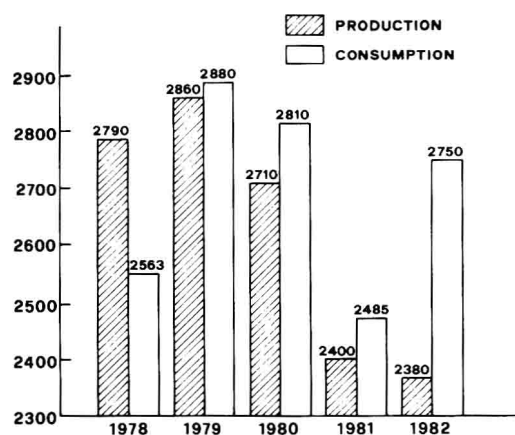


Figure 3. Trend of production and consumption of plastics in Italy over the years (thousands of tons).

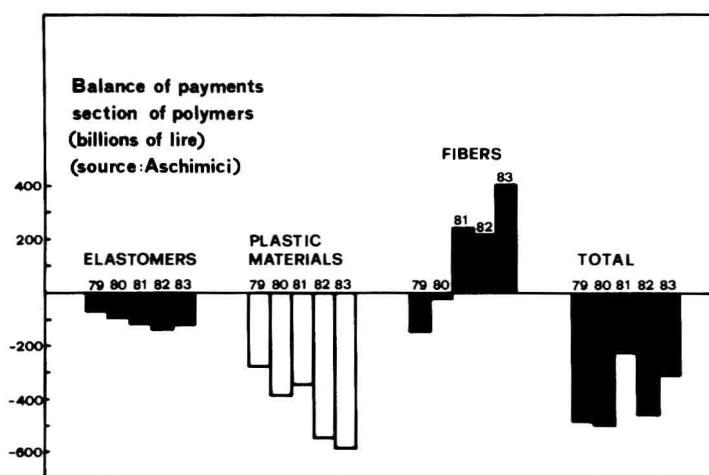


Figure 4a. Balance of payments of polymeric materials sector.

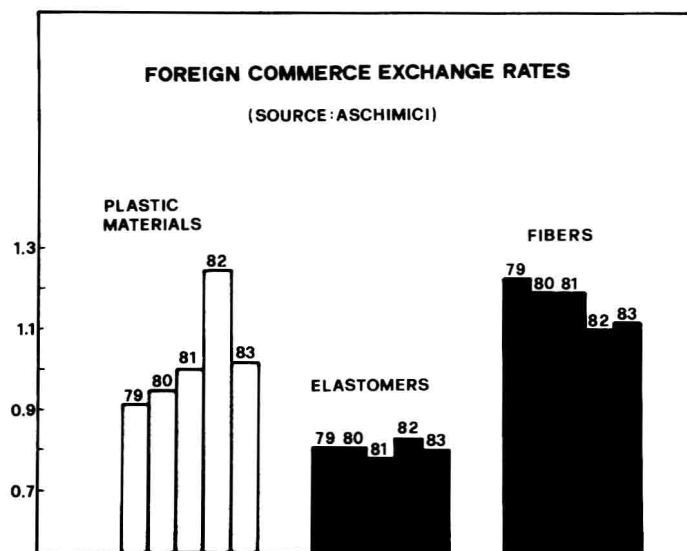


Figure 4b. Foreign commerce exchange rates.

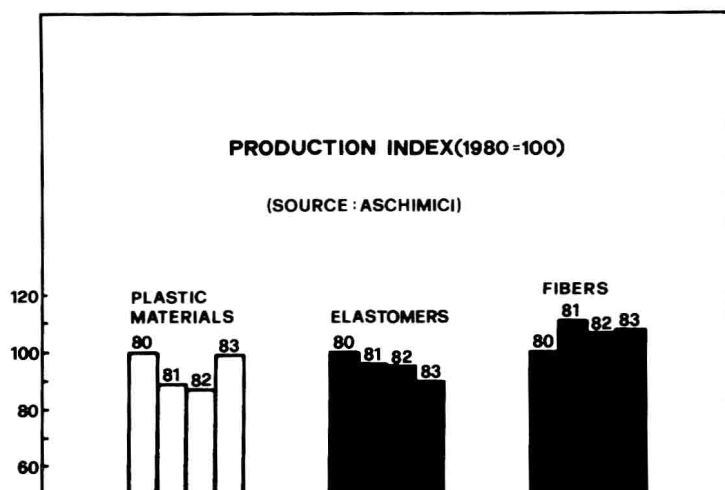


Figure 4c. Production index.

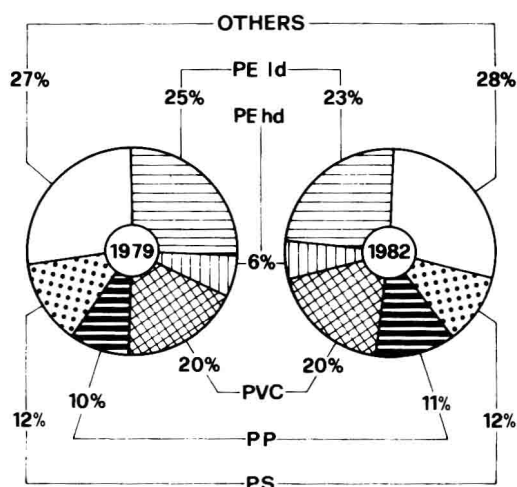


Figure 5. Breakdown of sales according to different thermoplastics, in Italy, over the years 1979 – 1982.

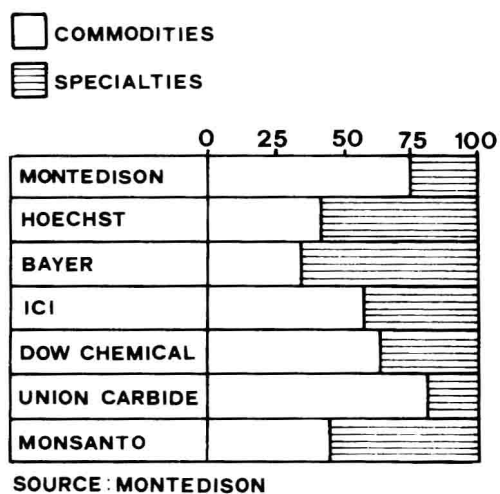


Figure 6. Between commodities and specialties in some chemical industries (1981).

the definition of objectives and strategies was the basic cause of this crisis, as this approach led to a far too optimistic forecast regarding market growth.

Consequently enormous new production plants for plastics (mainly bulk and commodities) were built, but unfortunately forecasts were proved completely wrong. The reasons may be found in the following facts:

- i) The general economic crisis all over Europe in relation to the first energy crisis.
- ii) Concentration of demand after the recession in some important sectors.

Another reason is that many important sectors for the application of commodity-type plastics had been completely opened and as a result the demand could only grow if respective industries expanded their actual market. This indicates that the turnover of commodity plastics is strictly dependent on the general economic trend. Signs of recovery have been observed since 1983. In fact this upward inclination in the European Plastic Material and Chemical Industry in general has reached a peak with a record in production of almost 13.3 million tons. However, this tendency must not be considered a turnabout but an interlude, of which advantage must be taken to improve the efficiency of plants and to eliminate excess capacity.

A steady recovery in the sector and the increased competitiveness of Italian industries on an international scale has provoked the start of vigorous innovation in both processing and products. This intervention cannot be further postponed and must foreshadow a change in the type of production whereby the predominating factors will be quality, suitability and performance.

The development of basic polymers should still be pursued, but above all great attention must be given to those special products having high mechanical, thermal and conducting characteristics.

In a country like Italy, advanced in technology but deficient in raw materials, the polymer chemistry industry should prevalently direct its steps toward the development of special polymers so as to reduce ever increasing competitiveness from developing oil producing countries. The low profitability in the commodity plastics business and the increasing threat of exports from the developing world means that companies in the sector (especially those belonging to non oil-producing countries) would look even more towards high performance plastics as a means of reducing the threat to their business.

In accordance with the principles of the international breakdown of labour it won't be long before the Italian Industry of Polymeric Materials mainly imports bulk plastics instead of actually producing them (with some exceptions due to the high degree of technology reached in some processes, for instance, in the case of polypropylene). It should concentrate on manufacturing specialities. Forecasts regarding the development of the Polymeric Materials Industry all conclude that the growing use of speciality polymers and their modified compounds as structural replacements for metals in the automotive, aerospace and construction industries will stimulate demand for these products at a very rapid rate over the next years. World producers of polymeric materials are preparing producers for a fundamental transformation; after an uncontrollable post-war quantitative expansion the sector must switch to a qualitative evolution, constantly concentrating production on high performance products for specialized and sophisticated applications.

The general trend for relaunching the sector is to pursue a strategical and technological innovation policy, particularly in the field of special polymers. Because the production of commodity plastics cannot be abandoned in the immediate future, the strategical and technological innovation policy for such materials should be aimed at the individualization of new models by using the instruments of Joint Ventures (see the

agreement between Hercules and Montedison in the case of polypropylene), with the objective of achieving a geographical presence on a worldwide scale. At the same time an effort should be made to reduce production costs.

The development of a competitive industry for special polymers at an international level must necessarily foresee the conversion of industries from "consumer" of technological innovations to "producer" of technological innovations.

This type of conversion can only be reached through enormous investments in research and development, which must have as an objective not only "know-how" but "know-why."* Public Research Institutes such as the CNR must actively participate in this enormous need for research in agreement with the fact that the main task of the CNR should be the development of a fundamental scientific culture contributing to technological innovation in priority sectors vital for the socio-economic progress of the nation.

It was this philosophy in the early 70's which led to the organization of "National Finalized Research Programmes" under which the FPFC and the sub-project polymeric materials have operated since 1980.

STRUCTURE AND EVOLUTION OF THE SUB-PROJECT "POLYMERIC MATERIALS": EVALUATION AFTER FOUR YEARS

The overall structure of the FPFC is schematically shown in Figure 8. The sub-project "Polymeric Materials" was born with the aim of contributing to the formation and development of a fundamental background, with the purpose of giving support to research activities having applicative interest.

Large research efforts, never attempted before, were undertaken in fields where the

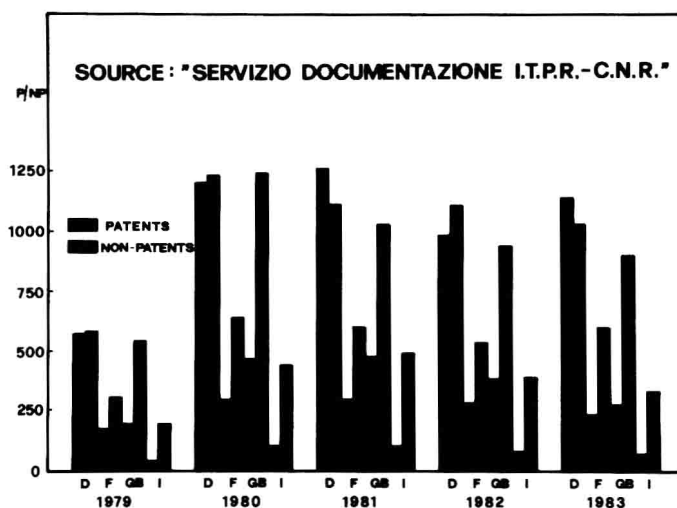


Figure 7. Number of scientific papers and patents of major West European countries over the years 1979 - 1983.

*The fact that in Italy there is the necessity to develop further research efforts in the sector of polymeric materials clearly emerges from the data shown in Figure 7 where the number of scientific papers and patents of major Western European countries is compared over the years 1979 - 1983.

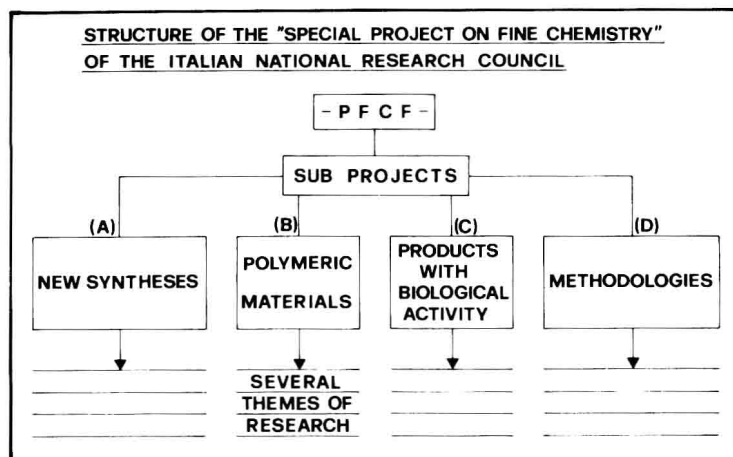


Figure 8. Overall of finalized projects on fine chemistry of Italian CNR.

Italian industry was traditionally present and highly active, in order to enlarge the basis of fundamental knowledge. At the same time research activities in highly innovative fields were started with the aim of constituting the cultural basis for possible interventions of the national industry in new and highly competitive sectors.

Following this philosophy, topics and research-lines were identified and activated, taking mainly into consideration input coming from the world of production. Teams were constituted including researchers belonging both to academy and company laboratories.

The overall structure of the sub-project "Polymeric Materials" and its evolution over the years is illustrated in Figure 9.

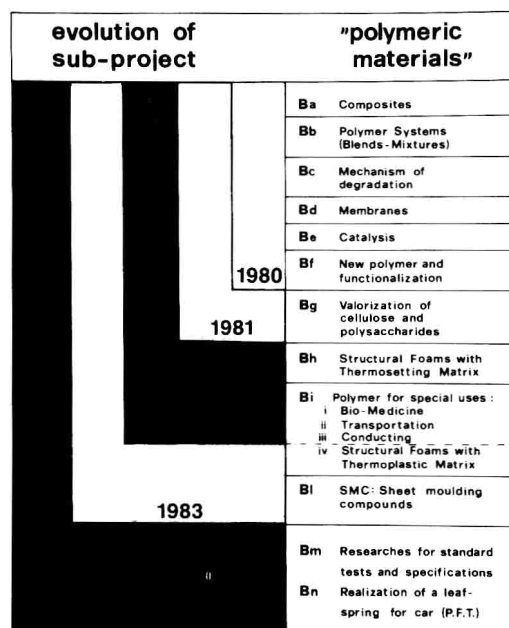


Figure 9. The structure of the sub-project "Polymeric Materials" and its evolution over the years.

Details of the research, relative objectives and principal results achieved for each topic will be illustrated during the Conference by the coordinators of the main themes.

On the whole the main effect of the research was aimed, on the one hand, at acquiring basic knowledge for the understanding of fundamental aspects of the chemistry and technology of polymers and, on the other hand, at contributing to the realization of new materials having special performances i.e., Speciality Polymers.

After 4 years work we may affirm that all activities developed have on the whole corresponded to the demands of national research with overall objectives in line with up-to-date international tendencies in the science and technology of polymeric materials.

Funds allotted for research activities of the Polymeric Materials sub-project, have grown over the years, moving from 850 million Lira in 1980 (funds refer to only half-year periods) to about 5.6 billion Lira in 1984. In terms of percentage compared to three other sub-projects the allotments rose in 1980 - 1984 from 19% to about 27% (see Figure 10).

In the period 1980 - 1984 an overall total of about 16.6 billion Lira was spent for research, about 4.8 of which was earmarked for equipment. These appropriations, relative to the investment items, have helped to renovate and improve the Italian "big facilities" park in this sector.

As shown by Figures 11 and 12 the number of researchers (usually expressed in terms of equivalent researchers (ER) and of operating units (OU)) has progressively grown from 1980 to 1984. 1980 ER = 128; OU = 77; 1984 ER = 449; OU = 183). The large participation of private and public company groups in the research activities must be pointed out.

The geographical distribution of the operating units is illustrated according to each institution in Figure 13. It is interesting to note how most of the industrial OU are concentrated in the North of Italy, in particular Lombardia and Piemonte. Even though large companies are present in the South, with large industrial plants, they do not develop any research activity in this part of the country. In the case of the small/medium companies situated in the South their deficiency is due to a low technological level and an insufficient awareness of the importance of research as a source of technical innovation. As shown by the data of Figure 14, where the distribution of the dimension of companies in terms of number of employees, is illustrated, together with the most important firms of

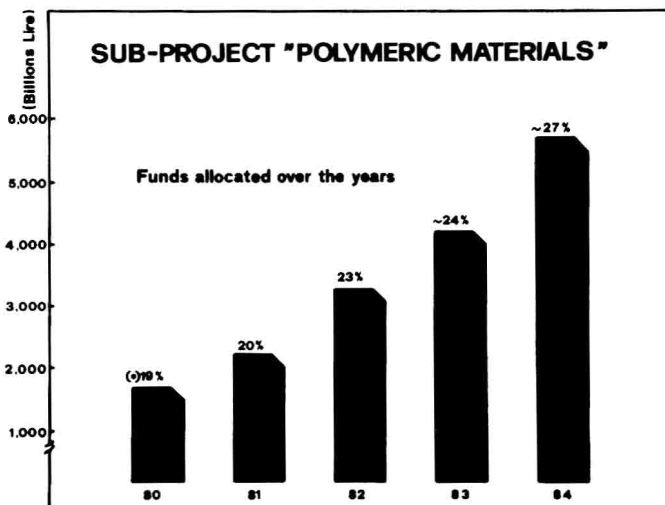


Figure 10. Funds allocated to the sub-project polymeric materials over the years.

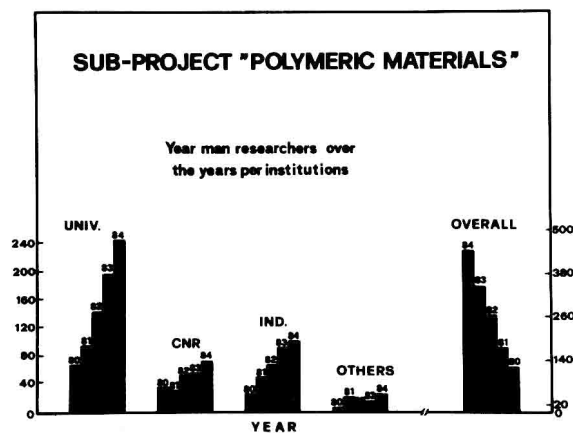


Figure 11. Years mass researchers, over the years, per institutions.

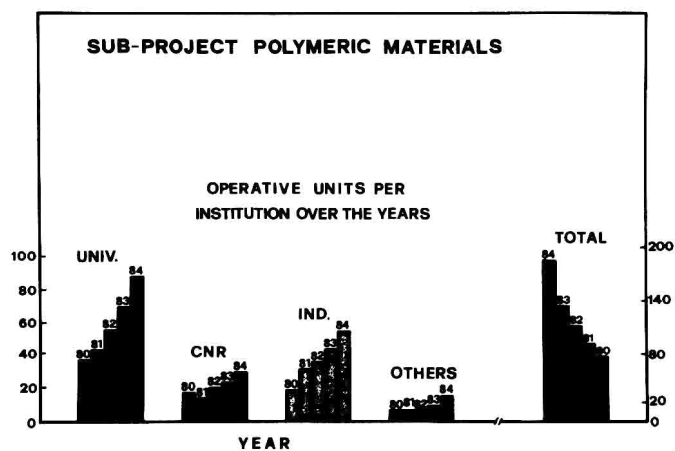


Figure 12. Number of operating units, over the years, per institutions.

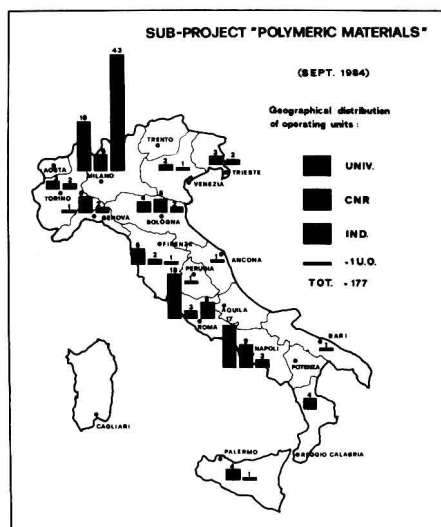


Figure 13. Geographical distribution of the operating units per institution.

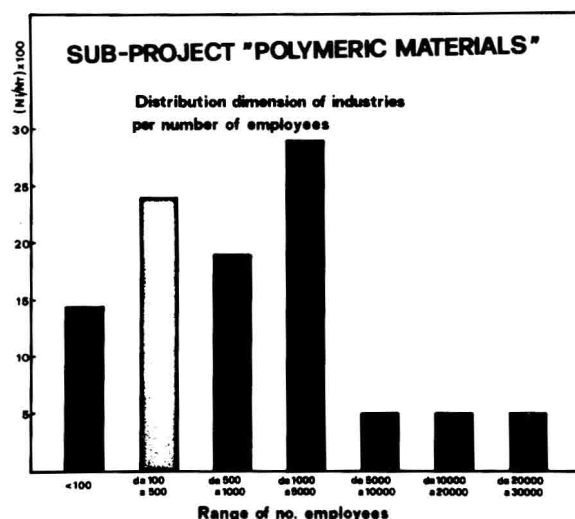


Figure 14. Distribution dimension of industries, operating in the sub-project "Polymeric Materials," per number of employees.

the sector (ENI, Montedison, SNIA etc.) many small and medium companies participate with their groups of research in the sub-project's activities.

An analysis of the quantitative participation of Research Groups for each institution allows us to draw the following conclusions:

- i) As far as the University and CNR are concerned it is possible to note how almost all groups working in Polymer Chemistry and Technology have joined the sub-project since 1980. The number of groups interested in polymer chemistry and technology belonging to CNR and the University is larger when compared to that of 1980.
- ii) Small and Medium Companies seem to have invested more in their research potential, whereas large companies tended to engage only a small part of their overall capacities.

After more than four years of activity it is possible to make a first significant summary and critically analyse the evolution of research and all the problems which have arisen and to express a general evaluation.

As shown in Figure 9, updated in September 1984, more than 260 papers of a good scientific level have been published (mostly in international journals). Most of these works are the result of collaboration between groups from different institutions (CNR, Universities, Industry). More than 30 patents have been registered, and some are being developed in various Italian companies (some also in foreign companies).

During the course of these four years technical know-how has been consolidated in new sectors thanks above all to the development of interactions between operative units working in public research institutes and in the laboratories of industry.

Academic research centers and their groups have often reoriented their research, converging on topics of major applicable interest while receiving part of the input from the industrial world.

The project has favoured, through the activation of new research topics and the purchase of equipment of high technology, the formation of highly specialized centers, where new skills have been developed and old skills consolidated.

In general, the results of the project can be considered satisfactory which leads me to