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SYNTHETIC POLYMER CHEMISTRY IN TWO DECADES

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On behalf of all of the conference participants, may I thank Otto Vogl, Robert Lenz and the polymer staff here for arranging this interesting conference. Arranging it in conjunction with the IUPAC Congress in Boston has made it possible to bring together an international group. And we also extend to Dr. Mortimer Apply, Dean of the Graduate School, our thanks for his welcome and the utilization of the facilities of the University of Massachusetts. It is only fair to say that Dean Apply graduated from the University of Michigan and although I might not hold with all of the things that he has said, he must have a sound background. I will try to keep my remarks rather light.

When Dr. Vogl suggested a lecture, I immediately said, "What kind of a scientific talk do you want?" And he immediately said, "Well, you are not to give a scientific talk." This makes you think immediately when somebody makes such a request that you are labeled as an old timer no longer carrying out a creative research. My first idea was to give in 45 minutes a review of the development of free radical polymerization and cationic polymerication. I spent a Saturday afternoon looking up some material and planning such a lecture, but when the list of people

that were going to be here became available, I realized it would be virtually impossible to do this in 45 minutes and acknowledge all the contributions of all the people in this audience.

The other possibility was that we might have some talk on perspectives in polymer science. We've been overworking that topic and I presume that some wisdom will come forth today in this discussion. Furthermore, I am not so sure that anyone knows very well what the perspectives in polymer science are, because I don't think you really can predict creative effort--what important problems will arise in the next few years which will make it apparent that some type of new breakthrough in polymer science has been achieved. So, I retreat to the position of making a few general remarks.

I should say to Dean Apply that he sees here a manifestation of great interest in macromolecular science--pure and applied--and throughout the world, not just here in the States. Of course, as you have amply pointed out, this is an area where your university has recognized this growth by the support of your Polymer Science Department. We hope that you continue to support this interdisciplinary effort. It is a very important effort of a large group of different types of scientists interested in related topics.

A few brief words about macromolecular science in the world and the States in several different categories.

We have this question of the growth of the educational endeavor in macromolecular science in university life which

is worldwide, which is not a systematic one, but one which is real. Thus, healthy and different education patterns will work if properly interested people participate and give leadership. We see also the very high interest in macromolecular science in the national chemical organizations of the world. We see the fantastic growth of the literature in macromolecular science which has occurred in the last 20 years. Any of these topics can take much time if developed, and would provide the basis of an address, and I don't propose to do that today. I merely want to remind us of these facts.

Now, let me make a few loose observations. The knowledge that macromolecules may have unique properties in solution, including biopolymers--and in the solid state has compelled scientists to work in this area.

Most men really need an outlet for self-expression and recognition for themselves and their work, an identification of some type in a group. By and large, this kind of process results in enthusiasm--spontaniety and worthwhile diversification. If the choice has not been based on some real need for intellectual expression, the group will change or modify or slowly drop from the scientific public view. We see this in many manifestations besides science. We see it in the many divisions of the American Chemical Society--we see it in the proliferation of the Gordon Conferences.

Macromolecular science is a natural for classification as an interdisciplinary area. Anyone who has read the program of this week's IUPAC meeting, recognized the enormous input of

scientific contributions across a very wide scope of chemistry, physics and biochemistry. The acceptance of an arbitrary classification of science and technology, whether logical or illogical--and man or civilization does not progress by logic--has been by a group obtaining new interesting results both of quality and quantity. But let me emphasize the term, quality. Let us not forget, however, that what you do is important and not how you classify it. As long as major areas of new research involve problems unique to macromolecules--and I make this assumption with some assurance--significant contributions will be made to the whole of science and technology. We should remember that any defensive attitude on our parochialism is useless and sterile. A positive attitude, namely that there is a vigorous healthy point of view to which people are oriented to attack major problems in science and technology, is the one to maintain.

I might say a very little about IUPAC and the macromolecular division. Some of you here are very much acquainted with the organization; others may not be so well acquainted. As you may remember, four years ago the Macromolecular Division of IUPAC was founded. There are six divisions of IUPAC--Organic, Inorganic, Analytical, Physical, Macromolecular and Applied. When the macromolecular group was a commission--that's a temporary group set up by a division--of the physical division of IUPAC, it was an extremely loose aglomerate of vigorous people. And we had symposia--we had interchange--of a rather major magnitude. It was quite apparent that here was a group interested in science. So the division was created through the efforts particularly of Sir Harry Melville, Professor Smets and Professor Wichterl.

And we have had this week a very clear indication of this intense interest.

Now a few remarks about the growth of education in the field of macromolecular science and technology. It is very apparent here at the University of Massachusetts. There are other interesting programs that have been started, all formulated in a different way within the academic framework of a particular university in the States and abroad. I don't think it would be useful to list the universities here in the States and describe the subtle differences of how groups report to the administration, or how their degree structures work and exactly what the interdepartmental effort is, but it is a rather interesting topic to probe. I urge any of you from abroad who are interested in this aspect of the problem, which is really a technique problem, to talk with people in the States. I think we see in the Japanese situation a very thriving, healthy academic posture in macromolecular science--mechanisms which have been made available by utilizing different departments in faculties of science and faculties of engineering. That is not to say that there is not growth in other areas of the world; I am just emphasizing these two. To repeat, interdisciplinary research efforts ought to be structured according to the way that best fits that particular country and that particular institution, to provide some visibility and some balance of all the scientific disciplines utilized.

I have mentioned also the intense interest of national organizations in macromolecular science. This stems from the fact that not only is the academic community involved, but also

because the industrial component is a very healthy one. The combination of the two, which are usually responsible for national societies, regardless of what type of governmental system is used, provides the reason for the identification of macromolecular science.

The growth of the literature is a phenomenal one--I see no reason to list all of the journals which publish material in macromolecular science--it's a formidable list. What we see is a healthy growth of journals publishing macromolecular science. We see, also, an extremely healthy growth of textbooks in macromolecular science in the last ten years. A rough figure of an increase of 90% for the last five years has been reported.

What of the future? It's a standard remark that many people make a number of times in any science. But we've all had friends tell us, and we've also thought it ourselves from time to time, that the real impact of macromolecular science is over. I can remember a good friend of mine making this statement in 1950. I am perfectly willing to listen to this argument, but am an eternal optimist and refuse to believe this pessimism. I do not propose to "second guess" creative investigation. I believe that specific molecular knowledge of structure will be all-important because the configuration and conformation of macromolecules in solution or in the solid state is the basis for their ultimate reactivity and derived properties. And new polymers will appear and new properties from these polymers will be made available. Specificity of reactions in synthetic macromolecules has, as yet, not been probed very deeply.

Finally, I want to touch on a point, and that is the use of the word, refinement. I regard this as a terrible work which should be used with reservation. We have always this situation in dealing with a field as we see it advancing as to whether we call a new development a refinement. On the basis of the fact that free radical polymerization of the conventional type presumably means a clean free radical in solution, any advance built on this classification might be called a refinement. Science advances by "refinement" and during the process we do much more than refine in our own little way for whatever contribution that is made. I think this is an important aspect to remember. We are apt to forget that new tools--new methods--new technology--is discovered. This is not refinement. Carbonium ion theory, for example, is a very typical area where you will hear numerous people suggesting that no one has been involved in new concepts for the last ten years. This is unfair. We don't want to fall "into the trap" of assuming that because someone continues to work in some aspect of free radical polymerization or anionic polymerization or any of what we might call major classifications that these represent refinements--they're not at all; they represent growth. Your chairman has indicated significant growth in free radical and cationic catalyzed polymerizations. It is one reason, I am sure, that the conference committee decided that they would have a stimulating program on these two subjects. I hope to participate and I thank you for your attention.