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For Environmental Research

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Coming to New York to receive this SOCMA award certainly highlights the past ten years of my research on the behavior of organic chemicals in the environment, not only for being selected by you for this award, but also for the privilege of sharing a few thoughts with you as representatives of an industry which is the cornerstone of modern technology and the high standard of living we all share. I am grateful for this honor and thank you for the hospitality extended to me.

I believe your selection was largely based on work concerning PCBs in the environment. As anyone knows who has followed the literature on PCB research and watched it grow from a handful of papers in 1970 to hundreds of papers each year, the implementation of controls for PCBs cannot be attributed to any one individual. The PCB story was written by a large number of scientists from our universities, industries, and government agencies as well as political leaders and concerned citizens. For my part, I wish to thank Professor G. Fred Lee who first encouraged me to study the occurrence of PCBs in the environment, Dr. Donald Mount, the director of the Environmental Research Laboratory-Duluth, who gave me unparalleled freedom to carry our views on the hazards of PCBs to the public arena, Drs. Jim McKim and William Brungs for their nomination to SOCMA, those who wrote supporting letters, and certainly not least, my family who endured the Duluth weather alone for so many days while I was on the road.

I would like to briefly summarize the PCB story to put perspective on the unique hazard PCBs posed to our environment. The early '60s saw three developments which were to meet head-on between 1967 and 1970. Gas chromatography was in its infancy and, although it gave pesticide research a "quantum jump" in terms of analytical capability, many analysts discovered mystery peaks which were residues of unidentified chemicals. These were given names such as "Avain Compound 1, 2, 3", "late DDT", or just "X" and "Y". The development of an interface for coupling a gas chromatograph to a mass spectrometer in the '60s found immediate application in residue analysis, and PCBs were first identified in 1966.

In the early '60s, the North American Mink Ranching Association experienced massive reproduction failures in mink ranches feeding Great Lakes fish. Research

in 1963 to 1965 showed that the fish were toxic to mink and that the effect was related to the DDT content of the fish. However, DDT was shown to be non-toxic at natural levels and some other toxicant was indicated which was related to the fat content of the fish as was DDT. By 1968 we confirmed the presence of PCBs in Lake Michigan fish, and subsequent tests showed PCBs to cause death and reproductive failures when fed at less than one tenth the PCB content of Lake Michigan fish.

The information I have indicates that PCBs received greater promotion about 1966 as heat transfer fluids and a host of other applications which led to a much larger environmental contamination then did their conventional use as dielectrics. In 1968, the Yusho epidemic in Japan surfaced, and the disease was attributed to intoxication by PCBs in rice oil which had been contaminated from heat transfer equipment. Therefore, PCBs surfaced as a problem because the exposure of PCBs to the environment increased about the time their presence could be readily detected, and major deleterious effects were observed in humans and other animals--all in less than five years.

In 1970, the first national meeting on PCBs was held in Duluth, and major health effects and environmental monitoring studies were initiated soon thereafter. It took approximately four years for the results of this research to show that PCBs were ubiquitous in the environment, that major bodies of waters such as rivers, the Great Lakes, and estuaries were contaminated to the extent that the organisms could not be used for food, and that PCBs had the potential for causing cancer. In 1975, the Director of our laboratory called for a national ban on the production and sale of PCBs, a view echoed by the 1975 National Conference on PCBs in Chicago. Several major litigations in 1975 and 1976 paved the way for strict - if not prohibitive - EPA regulations on PCBs which were based on a water quality criterion of 0.001 ppb. The entire story was climaxed by a legislative ban on PCBs aimed at phasing these chemicals out from U. S. industry in the near future.

I am aware of the fears that the "eco-freaks" will attempt to restrict the use of hundreds of other organic chemicals to the extent that major industries will be crippled. It is my opinion that, although action will likely continue on a few known hazardous chemicals which are widespread in the environment, it is unlikely that we will see many other chemicals which merit the unparalleled research and concern as did PCBs. What, then, is so unique about PCBs?

First, PCBs are so stable to biodegradation, photodegradation, and oxidation that most residues cannot be destroyed in the environment. Second, these same properties made PCBs attractive for scores of applications which led to extensive environmental contamination. Third, PCBs were one of the first chemicals discovered that are so fat soluble that fish accumulate hazardous tissue residues from water with concentrations far below those which directly affect the fish. It is this third characteristic which sets PCBs apart from the vast majority of other chemicals and to which I would like to address my remaining remarks.

When chemicals are discharged to a receiving water, those which are very soluble in oils and insoluble in water are rapidly absorbed by the fish oils through the gills in a predictable manner. If a fish is placed into contaminated water, the residue in the fish will increase rapidly for several days and then more slowly until the residue is more or less constant. The fish is said to be a steady state at this point. The maximum fish residue is directly proportional to the water concentration, and the proportionality factor is called the bioconcentration factor. Since the

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bioconcentration factor is a constant and an intrinsic property of the chemical, the residue in fish, after a few days of exposure, can be estimated if the bioconcentration factor and the concentration of the chemical is measured.

I believe our research will show that the bioconcentration factor is directly related to fundamental properties of organic chemicals such as the n-octanol/water partition coefficient which has been used for many years by the drug industry. It is known that chemicals with small partition coefficients (10 or 100) are rapidly excreted from the body whereas high values (10,000 or 100,000) indicate chemicals which persist in tissue. The persistence prolongs the effects and increases the potential of unwanted side-effects.

So here is the punch-line: PCBs have one of the highest partition coefficients and one of the highest bioconcentration factors ever found in a chemical. PCBs in water below common detection limits will accumulate enough in fish to kill mink if they are fed the fish and will exceed the FDA tolerance for fish intended for human food. Few other chemicals accumulate residues in fish 100,000 to 1,000,000 times the level in water, and these include chemicals such as DDT and methylmercury. It will not be surprising to me if we find that less than 0.1 percent of our organic chemicals will even approach PCBs with respect to this property.

It is true that science is the rigorous rejection of questions which cannot be answered and the grinding pursuit of those that can. Similarly, with respect to the responsibilities formalized by the Toxic Substances Control Act, we must continue to develop rationale which enables us to reject the majority of synthetic chemicals from rigorous testing so that our resources can be focused on those chemicals which present the greatest hazard. Our laboratory has been developing test methods for ten years, and it would be a simple task to compile a battery of tests by which all new chemicals should be evaluated. However, it is unlikely there are facilities or money enough to test each completely. It makes little sense to require a 30-day bioconcentration test for a chemical which as a low fat solubility which can be determined by a quick and inexpensive partition coefficient measurement. It makes little sense to conduct year-long chronic fish tests for a chemical like vinyl chloride which is so volatile it cannot be found in the aquatic environment, even immediately below a discharge. Clearly, volatile chemicals pose potential industrial hygiene problems, and research should be concentrated with these concerns.

It would not be reasonable for me to suggest that the research I have spoken of will by itself solve the problems with potentially hazardous chemicals we face as a society. No one is in a better position to minimize risks from chemicals than the chemical industry. I am well aware that many plant managers are completely unaware of the effects their practices may have, and we will undoubtedly learn together in many cases. At a recent meeting, a representative of a petrochemical company stated that their attorneys told their analytical laboratories "they didn't even want to know what was in the effluent in case it might become known". Such advice may have legal advantages in the short-term, but it reflects a total lack of understanding of the evolution of regulations. Regulations are largely reactionary in origin. It is the Yusho incidents, the Hudson Rivers, the Hopewell Virginias, that bring about strict regulation where self-regulation is not effective or non-existent. We are rapidly approaching the day when totally computerized GC/MS analyses will permit rapid characterization of waste effluents, and the lag time between discovery and action will continue to decrease. The action I speak of is most likely more and more burdensome regulations. Regulations

which are broad and ignore site-specific considerations will solve some problems and create jobs. However, our real hope lies in developing channels for sharing problems and technical information to minimize risks from potentially hazardous chemicals without retarding the development of new products and uses for chemicals.