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Guest Editorial - Forty Years of Chromatography: Perspectives and Future Trends

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GUEST EDITORIAL

FORTY YEARS OF CHROMATOGRAPHY Perspectives & Future Trends

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The Conference of forty years ago that we now honor is past history. Many of the distinguished contributors to it are no longer alive. But, we here demonstrate that they and their work are not forgotten, and that the foundations they laid upon which the chromatography of today is built were well laid.

The first Conference, 40 years ago, was sponsored by the Section of Physics and Chemistry of the New York Academy of Sciences, and dealt with "scope, theory, manipulation and application of chromatography." A few excerpts from the introductory remarks may be of interest:

Dr. Fruton (Yale University) suggested, about a year ago, that a conference on this subject be arranged. It was felt that it would be profitable to examine the state of our knowledge regarding chromatography, and especially to make it possible for workers use one method of adsorption analysis to come together with those using other methods, so that all methods might become more widely known. It was hoped that, through such a meeting, the chromatographic tool might become further sharpened and the realm of it proper use redefined.

This present conference developed from these ideas. It emphasizes the very fundamental fact that the improvement of an analytical tool is of major importance to the science, for many an improvement in analytical technique has changed the face of scientific theory. We recognize that the labor of the analyst is as endless as it is rewarding. One thinks, in this connection, of Walt Whitman's lines, "For it is provided in the essence of things, that from any fruition of success, no matter what, shall come forth something to make a greater struggle necessary." No sooner has one problem been solved, than the very solution of it raises others of greater subtlety. Here, we examine the new demands which success imposes, and we enjoy some of its fruits.

We have met here to discuss chromatography. It is on one of many analytical tools. Like so many of the procedures used by chemists to separate mixtures, it depends upon a partition process. In it, the substances to be separated are allowed to distribute themselves between two or more phases, and the operation is completed by a mechanical separation of the phases. In the case of chromatography, the partition occurs between a fluid phase and an interfacial phase. It is, in short, an adsorption process, and this distinguishes chromatography from other separation processes. In another respect, however, chromatography is similar to other separation methods, such as fractional distillation under reflux, countercurrent extraction, and countercurrent crystallization, in that advantage is taken of the partition in the most efficient manner possible, namely through a countercurrent application. It is partly in this respect that partition chromatography belongs here. It is worth emphasizing, perhaps, on the basis of these similarities, that much that will be said in this publication has implications beyond chromatography.

If I remember correctly, there was no registration fee for this conference, and no exhibitors. The meeting was held at The American Museum of Natural History, New York, and the lecture room was filled.

Instead of dwelling on the past, implicitly honored in this fine volume of the present, I would like to dwell on one or two aspects of the work of all of us that may be brought out because they are applicable not only to chromatography, but to all our activities.

At that early conference, I had quoted from Walt Whitman lines still relevant. In the flush of success of some elegant technique, some remarkable separation of a natural or man-made product into its components, or the development of a new or more efficient labor-saving machine, we are likely to think "at last, this is it!" The effort has perhaps been so great that by a kind of elastic reflex, knowing that we have conquered some past problem, and basking in present satisfaction, the needs of the future are allowed to be obscured.

This is perfectly natural. After a meal, you have to digest it before you get hungry again—and I hope that these few words of mine will not interrupt your present digestion nor the digestion of them interrupt the forthcoming papers.

Let us then open the door to the future a little. Surely present eyes have been the marvels that 40 years of R&D have brought out of chromatography; may the eyes of imagination conjure up glowing prospects for chromatography in the coming years.

As ever smaller samples of some mixture are expeditiously handled and separated into components, we must realize that we are steadily moving, asymptotically perhaps, to a limit—movement exemplifying Walt Whitman's words. Dr. A. J. P. Martin of Paper Chromatography fame, once told me that his hope was one day to manipulate single molecules. It would take a

remarkable pair of tweezers to pick one molecule by itself out of a mixture. Of course, present methods move in that direction.

We may again turn to principles, and perhaps speak of things you have already done, for I have been out of the field a long time. Would it be profitable to think of the chromatographic column as a potential field which you bring into being by the countercurrent flow of developer which biases the field in one direction? An electrostatic bias can be produced in another direction at right angles, giving a two-dimensional bias. Would a three-dimensional bias have advantages? (A magnetic bias, say?)

At one time it occurred to me that we had been separating cations on exchange resins. One of the cations was hydrogen ions, which could be recognized as hydrated protons. This semantic change of name immediately suggested that the other fundamental particle might be exchanged: electron-exchange polymers were born. Dr. Meyer Ezrin and I prepared the first electron exchange (redox) column. I think much unexplored potential remains here.

Well, this is perhaps enough. Thank you to have invited me to prepare this editorial, even though I left the field many years ago. Perhaps if I close this paper with a further quotation from that earlier conference, it may give you a sense of how far your field has developed in the intervening years. It may suggest what the state of the art was then, and areas that may still be fruitful of results: the papers of that conference may be found in the Annals of the New York Academy of Sciences, 49, Art. 2, pp. 141-326 (1948):

Ion exchange had not been brought formally under the scrutiny of the Conference, yet it is certainly assuming increasing importance as a tool which may be applied chromatographically. Accordingly, at the suggestion of one of the editors, Mr. Norman Applezweig was invited to write the

paper reviewing this field. It is hoped that this paper will aid in bringing before a wider audience the natural and synthetic exchange substances.

The non-uniformity of adsorbent surfaces was a subject of uniform concern and frequent discussion at the Conference. It therefore seemed proper to the Chairman to invite Dr. Leo Shedlovsky to contribute a paper on separations using foams and emulsions. The surfaces involved in mobile interfaces are likely to be of a sameness throughout the system and, thus, to meet some of the requirements hoped for in the discussion and be worthy of further study. Moreover, while chromatography has concerned itself almost entirely with solid-liquid or solid-gas interfaces, it has seemed to the Chairman that liquid-liquid or liquid-gas interfaces should also come into consideration here. The experiments by Schutz by the counter-current application of partition between the liquid-gas interfacial and bulk liquid phases. This paper by Dr. Shedlovsky may stimulate chromatographers to further investigation of the mobile interfaces.

It is worthwhile to report the general pattern which seemed, to the Chairman, to run through the Conference.

Chromatography, which was first devised as a tool applied empirically, has, in the last decade or so, become better understood. With understanding has come the flourishing development described by Dr. Zechmeister in his first paper. We are in the process, now, of further understanding and sharpening not only the classical Tswett chromatography, but also the elegant simplifications introduced by Tiselius and Claesson, and the ingenious and elegant "partition chromatography" of Martin & Synge.

It is probably correct to say that, while it may look as though some ultimate point has been reached in the refinement and subtlety of

chromatography as these have been revealed in the foregoing papers, yet experience allows us to prophesy that there will be no end to progress. It is quite reasonable to expect that some of those who attended the Conference or will read these papers will be stimulated to important new ideas.

One area of investigation in which there is evident need for continued research and inspiration--continued research and inspiration are immanent in the foregoing papers--is that which connects adsorbability with chemical or physical properties of molecules. It was implied, in the discussions, that we should expect no simple relationship to be found here. Yet, I venture to wonder if we might not, through some principle of exclusion, find a simple set of relations. We may find that, under given circumstances, a large proportion of the factors which might theoretically add complexity to this relationship drop out instead, leaving only one or two controlling factors to be dealt with.

A basis for such a hope as this may be found in the work of Tiselius and his group. Here, in the face of the complexities of chromatographic theory so well delineated by Dr. Thomas, simplifications were wrought which have brought the theory under practical control. An example of such simplification is the use of the displacement developer, which with one stroke can control the behavior of the rest of the adsorbates in the column. Perhaps, with this precedent, we can look for further simplifications, whether in technique or theory or in relations which connect structure and properties of molecules with their behavior in the column.

The need for standardized adsorbents, which was stressed especially by Dr. Zechmeister, has already been mentioned.

Those who attended the Conference and who will read these pages are indebted to the authors. They gave freely of their time and, in some cases, came from far away to contribute to the success of the Conference and the existence of this monograph. Theirs was a real act of faith in the objective of these conferences: The free interchange of scientific knowledge and ideas among scientists.

I closed that long-ago conference by quoting Bacon's advice of even longer ago: "We advise all men to think of the true ends of knowledge, and that they endeavor not after it for curiosity, contention, or the sake of despising others, nor yet for reputation or power or any other such inferior consideration, but solely for the occasion and uses of life."

Thus I try, by inspirational repetitions to tie the past to the present and, in thanking you, again turn a little toward the future.