From polymers or colloids to polymers and colloids

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The history of polymers and colloids is almost inextricably linked with the name Hermann Staudinger. Before 1920, macromolecules were mostly imagined as colloids and, consequently, their exact chemical structure was not completely clear. It was assumed that many small molecules assemble into larger colloids through weak intermolecular interactions. Staudinger's investigations, which were published 100 years ago [1], enabled a first detailed understanding of the chemical structure of polymers and macromolecules. Giant molecules linked by covalent bonds were a novelty at that time and nothing less than a revolutionary idea, compared to the assembly of well-defined small molecules into larger colloids. At this time, Staudinger experienced great rejection for his idea, but in the end, he was proven to be right.

About a decade later, the theory of macromolecules, as Staudinger himself called these molecules [2], had been established in the scientific community. In particular, the characterization by means of viscosity could also convince the supporters of the colloid theory and all skeptics that polymers consist of a large number of covalently linked molecules. Hermann Staudinger himself finally linked the terminology and, thus, connected the fields of polymer and colloid science [3].

Since this time, polymers and macromolecules have developed significantly and have also had a lasting impact on our daily life and society. Many modern products are no longer conceivable without these materials. But even today, the field of macromolecular chemistry still has challenges to be solved. In contrast to the early times, we are not dealing with fundamental questions of the structure of polymers—we have to deal with tangible problems. Microplastics, sustainability, and recycling are the greatest current challenges of today's research and application of polymers. In connection with the triumphant advance of polymers, we now have to deal with the “plastics legacy” [4].

Polymer science has become a very important field of research since 1920. At that time, one single research group worked on this topic—today, there are more than 175 research groups in Germany investigating polymers and related topics [5]. However, the macromolecular research landscape has also changed persistently. While in 1920, the most important questions were about the structure, the existence, and the characterization of macromolecules, today, biologists, chemists, physicists, materials scientists, and physicians (and other research areas) deal with a multitude of possible applications and fundamental questions. Thereby, the increasing complexity of the materials enables completely new and non-imaginable applications, from metal-free batteries [6] and intelligent polymers [7] to new 3D-printed materials [8]. Medical applications of polymers in the area of tissue engineering [9] or drug delivery [10] also influence the modern medicine.

Still, there is a close connection between colloid and polymer science. Polymers can be converted into colloids in a variety of ways. Macromolecules can be converted into

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colloidal structures either directly during synthesis (e.g., applying suspension polymerization [11]) or using certain other techniques (e.g., dispersion processes [12]). In addition, more and more polymer-based colloid systems are being utilized, e.g., for drug delivery applications [13]. Therefore, the two subject areas will continue to be closely linked in the future.

In summary, it can be stated that after 100 years, macromolecular chemistry has become an important part of the research landscape and has produced a large number of applications and products. Nonetheless, it faces fundamental challenges that need to be solved so that the second 100 years will be a success story similar to the first century. In addition, the connection between colloid and polymer science will synergistically influence both fields and lead to the expectation of further outstanding findings.

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