POLYMER MONOLITHS: PAST, PRESENT AND PERSPECTIVES

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The method of preparation of porous polymer monoliths with physical nanostructure and chemical functionality controlled at the polymerization step has been theoretically designed, experimentally developed, and reduced to praxis. These monolithic materials do not require any additional treatment and are prepared directly in the shape of ready-to-use devices including columns, disks, tubes, and thin layers as needed for the desired practical application. The properties of these nanoscale defined monoliths are formed from the selected monomer molecules, through the formation of nanosized polymer chains with their simultaneous cross-linking leading to nanonuclei that separate as a solid phase, followed by the formation of microglobules, which aggregate into the clusters that create the desired rigid polymer scaffold. The final design represents a very clear example of fractal structure and has received the internationally accepted name POLYMER MONOLITHS. The scaling of the monoliths is simple since properties of the material are defined using strictly controlled synthetic conditions. The monoliths represent a unique combination of micrometer large channels enabling high flow rates of liquids at low backpressure together with the network of meso-, micro-, and nanopores that have the major impact onto the extent of the adsorption surface. The unique mechanism of mass transport of separated compounds in the flow-through channels from the liquid phase to the solid phase surface allows for an enormous increase in speed of all separation operations carried out with monoliths. The high-speed separations are extremely valuable in analysis/isolation not only on microlevel, but also in the downstream processing in biotechnology processes, especially when the complex structures, e.g. viral particles, are in question. Beside very high yields, fully scalable processes also high purity products are enabled by using monoliths, far outperforming any other chromatographic resin. As a result, monoliths are already used in >150 different gene therapy clinical trial projects and some of them are already on the market. As a consequence, multi Billion EUR business is expected to be generated within next decade. Monoliths are therefore regarded as strategic technology to produce viral vectors for gene therapy purposes. The well-known and very fresh examples of the use of polymer monoliths, such as, for example, immobilized enzyme reactors (IMERs) conjoined with high performance separation of product mixtures, will be demonstrated and discussed.