Characterization of Molecular Structure of Paint Binders Using Light Scattering and Related Techniques

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Molecular structure of polymer binders used for paint manufacturing affects not only many of their properties, but also brings valuable information about kinetics of polymerization reactions. The term molecular structure includes molar mass distribution and topology of macromolecular chains. Size exclusion chromatography (SEC) is nowadays the dominant technique for the determination of molar mass distribution. However, in its conventional form when the molar mass is obtained from a calibration curve established by standards of known molar mass, the technique suffers from several limitations. Most importantly, the obtained molar mass distribution is a priori incorrect as the sample being analyzed is typically of different chemical composition than that of standards used to calibrate the SEC columns. In addition, the polymer standards are linear while polymer binders often contain branched macromolecules. This fact further increases the errors of molar mass obtained from calibration curve. The limitation of conventional SEC is the most effectively solved by coupling an SEC chromatograph with a multi-angle light scattering (MALS) detector which measures correct molar mass from the intensity of scattered light irrespective of chemical composition and molecular topology. In addition to the molar mass, the MALS detector yields radius of gyration which describes size of macromolecules. Simultaneous determination of molar mass and radius of gyration allows studying the long-chain branching of polymer chains.

Although SEC represents one of the most frequently used techniques of polymer characterization, its ability to separate certain types of polymers is strongly limited. Typical polymers difficult for SEC are those containing ultra-high molar mass fractions prone to shear degradation or highly branched polymer molecules with tendency to get anchored in pores of SEC column packing. Acrylic copolymers prepared by emulsion polymerization are typical examples of polymer binders that cannot be reliably analyzed by SEC-MALS. Asymmetric flow field flow fractionation (AF4) is an alternative analytical separation method which completely eliminates anchoring of branched macromolecules and strongly reduces shear degradation of macromolecules with very high molar mass.

The lecture offers a brief overview of the fundamental principles of MALS, SEC and AF4 and presents several examples of the application of the techniques for the characterization of molecular structure of various paint binders with special focus on acrylic emulsion copolymers including novel types with traditional monomers partially replaced with bio-synthetic monomers based on methyl esters of fatty acids from various vegetable oils.

References:

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