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Ralf Dümpelmann has been educated as Chemical Engineer in Karlsruhe and ETH Zürich with a doctorate about catalytical systems. After working for 20 years in the chemical industry, last as Director of the R&D Center Formulation Technologies at Clariant, he decided to start his own business Inolytix AG in 2014. He is passionate about novel analytical systems, many industrial applications and bringing together the right people, also called “open-innovation”.

Abstract

Surface properties of graphenes, carbon blacks and carbon fibers by IGC

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Nanomaterials as carbon blacks, graphenes and CNTs are being used as additives in many materials as tyres, semi-conductive and/or black polymers and composites. The integration into the matrix is significantly determined by the surface properties.
Interaction properties of the surfaces can quantitatively be determined by a method called Inverse Gas Chromatography (IGC) which is based on the adsorption behavior of up to 20 different polar and apolar molecular probes. The principle is known since 25 years, but some misleading concepts as “nominal surface coverage” and poor operational execution brought some disappointments to this great, versatile method.
During 20 years and over 750 projects for the industry, we significantly improved IGC towards a reliable method to characterize surface properties of nanomaterials, powders and even fibers. Examples with different graphenes, carbon blacks and even carbon fibers are showing the large variability of different products and the value of this method.
IGC at very small, “infinite” concentrations (IGC-ID) delivers quantitative values of disperse surface energy, nanoroughness, overall polarity and acid-base (electron donor/ acceptor) properties. The nanoroughness, for example, is based on the different adsorption properties of linear n-alkane, branched isooctane and cyclooctane and delivers a detailed picture of the size exclusion or solution behavior on a molecular level.
IGC at high, “finite” concentrations (IGC-FC) uses a new setup to saturate the surface with a selected probe molecule, e.g. n-heptane, at a defined partial pressure and at moderate temperatures, e.g. 30 °C. The desorption curves contain information about the heterogeneity of the surface. Calculation of the Energy Distribution Function (AEDF) provides quantitative information e.g. the distribution of two different adsorption sites. In addition, the adsorption isotherms are being used to calculate the specific BET surface area for this probe molecule and a temperature-programmed desorption quantifies very strong, irreversible adsorption.
The examples of carbon blacks, graphenes and carbon fibers show, that industrial users of nanomaterials are dealing with very different qualities, sometimes even from batch-to-batch, which makes it even more difficult to understand and control the behavior in the application of nanomaterial in industrial products.