Surface Characterization of Fillers, Fibres and Polymers by iGC for Developing Composites

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Inverse Gas Chromatography (iGC) is a commonly used technique to characterize solid surfaces. Different physicochemical properties of solid materials that can be determined with iGC including surface energy ($\gamma_s^d, \gamma_s^{ab}, \gamma_s^t$), Lewis acid and base constants and therefore the specific pair interaction parameter (K_a, K_b, I_{sp}), solubility parameter (δ_T, δ_D, δ_P, δ_H), glass transition temperature (T_g), Work of Cohesion and Adhesion (W_{coh}, W_{adh}) and so on. The importance of surface energies is well-known and proved by many scientific papers in the case of composites. The Surface Energy Analyzer (SEA) is the new generation of inverse gas chromatography instrumentation, which would allow all the mentioned properties to be measured directly and automatically with its unique injection system and software.

In our previous study, the surface energies of untreated and oxidized carbon nanotubes and nano-clays and the polyurethane were measured individually by SEA system. The thermodynamic work of cohesion and adhesion were calculated from the surface energy components, which have shown linear relationship with the mechanical properties of the composites, the results are listed in Table 1. The effectiveness of an additive and a matrix combination can be predictable from the work of cohesion and adhesion values based on the surface energy values of the individual components.

In our most recent study in collaboration with Deakin University, the surface energy and the acid-base properties of ultrafine silk powders as new lightweight composite filler was measured by SEA system and the surface energy values were correlated with the cohesiveness and flow ability of the silk powders [1].

The inverse gas chromatography technique like SEA is a powerful technique to determine different physicochemical properties of different solid materials which are critical variables for manufacturing processes and product development. This presentation will summarize recent studies where IGC has been used to investigate surface modification of filler materials and its correlation to adhesion phenomena.

Table 1.: Thermodynamic works of cohesion and adhesion values and mechanical performances of composites

	W_{coh} [mJ/m^2]	W_{adh} [mJ/m^2]	$\frac{W_{adh}}{W_{coh}}$	Tensile Modulus [GPa]	Tensile Strength at break [MPa]
AR-MWNT/PU	160.4	293.4	0.55	1.93±0.17	60±7
MWNT-COOH/PU	178.8	366.2	0.49	1.53±0.14	56±6
AR-nanoclay/PU	188.3	404.3	0.47	2.05±0.15	54±11
fNCO-nanoclay/PU	104.9	121.9	0.86	2.31±0.12	71±7

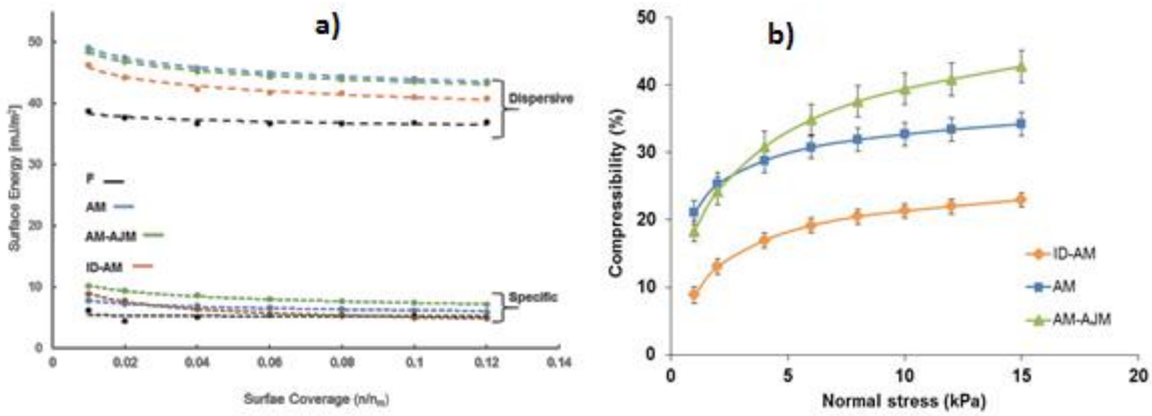

Figure 1. a) Profiles of surface energies and b) compressibility of silk powders [1]

[1] R. Rajkhowa, A. Kafi, Q. T. Zhou, A. Kondor, D. A. V. Morton, X. Wang; Relationship between processing, surface energy and bulk properties of ultrafine silk particles, Powder Technology 270 (2015) 112-120