Editorial corner – a personal view

Molecular architecturing in thermosets – Still chance ‘at the bottom’?

J. Karger-Kocsis¹, S. Grishchuk²

¹Department of Polymer Engineering, Faculty of Mechanical Engineering, Budapest University of Technology and Economics, H-1111 Budapest, Hungary

²Institute for Composite Materials, TU Kaiserslautern, D-67663 Kaiserslautern, Germany

Major goal of materials science is property improvement. Modification of thermosets with fillers and reinforcements of micro- and macroscale appearance is considered as one of the right tools for property tailoring. In the meantime, the related knowledge and know-how gained is successfully transferred to nanoscale resulting in numerous thermosetting nanocomposites. Toughening of highly crosslinked resins has been under focus of interest all the time. Common aspect of toughening strategies is the creation of micro- and nanoheterogeneous systems in which cavitation/debonding-induced shear deformation of the matrix resin prevails. It is widely accepted that the molecular network of the crosslinked resin itself is homogeneous. This is not obvious since resins and hardeners are multifunctional compounds, and thus the reactivity of primary and secondary functionalities are different. Depending on reaction conditions, this can influence the compatibility of growing chains during cure. Therefore, kinetically driven phase separation or nanostructuring could occur. Several experimental and theoretical reports suggest formation of a nanoheterogeneous structure of thermosets. This may be expected when intra- and intermolecular crosslinking occur separately which may happen during co-crosslinking (e.g. styrene crosslinked vinyl ester (DOI: [10.3144/expresspolymlett.2013.38](https://doi.org/10.3144/expresspolymlett.2013.38))), formation of interpenetrating networks, and different chemical pathways in hybrid resins. However, the frequently observed nanoscale nodular morphology in epoxy resins (DOI: [10.1016/j.matlet.2015.12.066](https://doi.org/10.1016/j.matlet.2015.12.066)) may be an experimental artifact (DOI: [10.1016/j.polymer.2014.](https://doi.org/10.1016/j.polymer.2014.06.030)

[06.030](https://doi.org/10.1016/j.polymer.2014.06.030)). Unfortunately, the range of the experimental techniques for morphology detection of thermosets is limited. Moreover, no physical etching techniques proved to be artifact-free. There are several possibilities for network architecturing. The easiest and widely practiced way, is to control the network density. This, however, still yields a quasi-homogeneous morphology. Can we introduce some regular inhomogeneity in the network structure in order to improve toughness and other mechanical parameters? Recent strategies focus on the creation of ‘partially reacted substructures’ (DOI: [10.1021/acs.macromol.5b00677](https://doi.org/10.1021/acs.macromol.5b00677)), build-up of dangling chains in the network (DOI: [10.1177/1045389X13478275](https://doi.org/10.1177/1045389X13478275)), controlled topological structuring (DOI: [10.1016/j.polymer.2016.07.038](https://doi.org/10.1016/j.polymer.2016.07.038)), also via vitrimer chemistry (DOI: [10.1039/C5SC02223A](https://doi.org/10.1039/C5SC02223A)). The outcome may be comparable with that of tougheners incorporated via reaction induced phase separation. Further possibilities for network tailoring can be expected from molecular dynamics simulation studies (e.g. DOI: [10.1021/acs.macromol.5b01183](https://doi.org/10.1021/acs.macromol.5b01183)). So, there is still ‘plenty room at the bottom’ (R. Feynman, 1959) for thermosets - why not explore it?

Prof. Dr. Dr. h.c.
József Karger-Kocsis
Editor-in-Chief

Dr. Sergiy Grishchuk

*Corresponding author, e-mail: karger@pt.bme.hu
© BME-PT