MAR05-2004-006602

Abstract for an Invited Paper
for the MAR05 Meeting of
the American Physical Society

Network Phases of ABC Triblock Copolymers

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Fundamental exploration of the melt state phase behavior in linear ABC triblock copolymers has uncovered a fantastic array of over two dozen unique morphologies in just over a decade of limited scrutiny. These structures range from simple three-domain analogs of the classic diblock copolymer phases to exquisite "decorated phases" characterized by the presence of A/C interfaces not inherently required by the natural connectivity of the copolymer. In this presentation I will focus on our extensive research efforts targeting the discovery of multiply continuous network phases within the expansive ABC parameter space. Adopting a strategy involving block connectivities precluding A/C interface formation and compositions aimed at breaking symmetry between two and three domain lamellar regions, we synthesized a series of 43 poly(isoprene-*b*-styrene-*b*-ethylene oxide) (ISO) triblock copolymers (ranging from 15 to 25 kg/mol) to systematically explore network formation in ABC systems. Employing a battery of complementary analysis techniques including TEM, SAXS (static and under reciprocal shear), dynamic mechanical spectroscopy and static birefringence, coupled with mathematically generated level set models that bridge real and reciprocal space, we have identified a total of three independent network phases formed in this single triblock copolymer system. Two cubic network phases, Q^{230} (core-shell double gyroid, $Ia\bar{3}d$) and Q^{214} (alternating gyroid, $I4_132$), and an unprecedented orthorhombic network phase, O^{70} ($Fddd$), were found to define a significant region of contiguous phase space, with order-order transitions (OOTs) found between network phases in some samples. Quite remarkably, the topology of each of these networks shares a common structure based on ordered arrays of connected 10-node loops, with each node trivalently joined to other nodes in the network. The universal presence of such networks in other ABC systems will be discussed.