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NANOSTRUCTURED POLYMER BLENDS

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AMSTERDAM • BOSTON • HEIDELBERG • LONDON

NEW YORK • OXFORD • PARIS • SAN DIEGO

SAN FRANCISCO • SINGAPORE • SYDNEY • TOKYO

William Andrew is an imprint of Elsevier



TB383
N186..0

2014

William Andrew is an imprint of Elsevier
225 Wyman Street, Waltham, MA 02451, USA
The Boulevard, Langford Lane, Kidlington, Oxford OX5 1GB, UK

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Library of Congress Cataloging-in-Publication Data

A catalogue record for this book is available from the Library of Congress.

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

ISBN: 978-1-4557-3159-6

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www.adimps.com



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Nanostructured Polymer Blends

Preface

Polymer blends are an effective means of combining polymers to obtain desirable properties from each constituent polymer without preparation of specific copolymers. Polymer blends are preferably two-phase materials so that properties of constituent polymers are retained, while in miscible polymers properties are likely to be averaged. In concert with interest in nanotechnology, the phase dimensions of a dispersed phase in polymer blends can vary from micrometer, to nanometer through to miscibility on a molecular scale. Polymer blends with nanometer dispersed phase are the subject of this book.

Nanostructured polymer blends have been classified into various combinations, polymer types and methods of preparation in developing the chapters of this book. Important questions to be addressed are: How can phase dimensions be created in the nanometer scale when polymers are in blends? Will a nanophase blend undergo particle growth through diffusion to form larger particles? Are special dispersion methods required or can the blends be created by phase separation from an initially miscible blend? Characterization techniques are available to assess structure, morphology and properties of nanostructured polymer blends.

Phase morphology in nanostructured blends could be obtained by shear dispersion of the minor phase if relative viscosity and interfacial tension was such that droplets are disrupted into smaller and smaller size until nano-dimensions are reached. Polymers that are miscible at elevated temperature could be cooled giving spinodal decomposition into a dispersed nano-phase. Phase separation by crosslinking of one polymer component will entropically separate the other polymer, particularly at the gel point, which may be accompanied by spinodal decomposition. Crystallization of one polymer will exclude and hence separate the second polymer. If kinetics and thermodynamics are suitable a nanostructured polymer blend can be formed. Theoretical modeling based upon solubility parameters, interactions parameters and volume fraction theories are applicable for an understanding of nanostructured polymer blends.

Nano-phase formation and stability can be achieved through use of compatibilisers since the interface is critical in dispersed particle stabilization. Blends where both polymers are thermoplastics are a convenient starting place for investigation of nanostructured blend

formation. Thermosetting polymers combined with block copolymers gives potential for control of morphologies via block copolymer design and the time–temperature– transformation of the thermosetting polymer. If the copolymer is of hyper-branched type then further options are available for phase separation during cure of the thermoset. Combinations of block copolymers allow fine tuning of blend morphology by choice, arrangement and molar mass of the respective polymer blocks.

Specialty polymers such as hydrogels and liquid crystalline polymers can form nanophases due to gel structures or mesogen domains within one of the phases. Hybrid materials consisting of a disparity of size, source or composition can evolve into nanostructured materials with unique property combinations. The materials may have specific interfaces leading to explicit thin film properties, hierachal structures and stimulus responsive character. Formation of a percolation network or co-continuous structure can impart electrical conductivity. Nano-polymer particles dispersed in a polymer can have a disproportionate role in thermal ageing due to polymer ageing dependence on free volume contributions. A further contribution is retardation of degradation as found for nano-composites and fire retardation. Polymer blend systems with controlled dispersed phase size and morphology in the nano-scale are being developed as part of the thrust into nano-materials. Unique property combinations and specificity are leading these materials into new applications with commercial development to follow.

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