SECURITY CLASSIFICATION OF THIS PAGE

(2)

AD-A242 732

REPORT DOCUMENTATION PAGE

DTIC ELECTE NOV 13 1991 C D

1b RESTRICTIVE MARKINGS	
2a SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION / AVAILABILITY OF REPORT: Unlimited
2b DECLASSIFICATION / DOWNGRADING SCHEDULE	
4 PERFORMING ORGANIZATION REPORT NUMBER(S): Final Report	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a NAME OF PERFORMING ORGANIZATION: University of Southern California	6b OFFICE SYMBOL (If applicable): MC 1211
7a NAME OF MONITORING ORGANIZATION: Office of Naval Research	
6c ADDRESS (City, State, and ZIP Code): Department of Chemical Engineering, University of Southern California, Los Angeles, California 90089-1211	7b ADDRESS (City, State, and ZIP Code): 800 North Quincy Street, Arlington, Virginia 22217-5000
8a NAME OF FUNDING / SPONSORING ORGANIZATION: ONR/DARPA	8b OFFICE SYMBOL (If applicable)
9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: ONR N00014-88-K-0302	
8c ADDRESS (City, State, and ZIP Code): 800 North Quincy Street, Arlington, Virginia 22217-5000	10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO	PROJECT NO	TASK NO	WORK UNIT ACCESSION NO

11 TITLE (Include Security Classification)
The Behavior of Polymers Filled with Monodisperse Polymeric Beads

12 PERSONAL AUTHOR(S)
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13a TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Final	FROM 5/1/88 TO 8/14/91	1991, November 4	3

16 SUPPLEMENTARY NOTATION

17 COSATI CODES			18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Filled Polymers; Crosslinked Monodisperse Polymeric Beads; Rheology

19 ABSTRACT (Continue on reverse if necessary and identify by block number)
--Project Summary attached--

91-15819

20 DISTRIBUTION / AVAILABILITY OF ABSTRACT	21 ABSTRACT SECURITY CLASSIFICATION
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	Unclassified

22a NAME OF RESPONSIBLE INDIVIDUAL	22b TELEPHONE (Include Area Code)	22c OFFICE SYMBOL
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DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

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The Behavior of Polymers Filled with Monodisperse Polymeric Beads

Grant/Contract N00014-88-K-0302, R&T code 413m010

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FINAL REPORT

Techniques have been developed for preparing crosslinked spherical polymer beads, monodisperse in size, composed of polystyrene and derivatives, polymethyl mechacrylate (PMMA), polyethyl methacrylate, polybutyl methacrylate and polymethylacrylonitrile [1-3]. Control of the crosslink density gradient was acheived by semi-continuous copolymerization [4, 5]. Monodisperse bead diameters are controlled between 150-800 nm in a single stage synthesis, with sizes reproducible to ± 5 nm in a given run and crosslink densities vary from 1-20 mol%. Particle nucleation onto preexisting polymer seeds was conducted in a multistage polymerization yielding compositionally complex beads up to 4 μm in diameter [6].

Beads are characterized by a wide variety of techniques. A new procedure has been developed to determine the crosslink density by equilibrium swelling on an ultrafiltration membrane [4].

Techniques for mixing polymer beads and polymer matrices have been developed [7]. The rheological properties of polymeric composites, of beads and matrices, are often insenstivie to the size and crosslink density of the beads [8]. Rheological changes are particularly sensitive to chemical composition in a polar matrix. In general, reduced rheological increases are realized for composites in which bead and matrix are compatible [9, 10]. The steady shear viscosity of composites, consisting of a PMMA matrix, filled with 20% of crosslinked beads of varied composition, exhibits time dependent increases on aging following shearing [10].

Changes in steady shear viscosity and dynamic moduli depend on the dispersion of particles in a polymeric matrix. Incompatible particles form large clusters, which are destroyed at high shear rate, producing a highly non-Newtonian response. Clusters reform rapdily on aging at elevated temperatures. For compatible composites, crosslinked particles are randomly dispersed on mixing and remain so on aging, producing (almost) Newtonian behavior.

Technical Reports and Journal Articles

1. D. Zou, V. Derlich, K. Gandhi, M. Park, L. Sun, D. Kriz, Y. D. Lee, G. Kim, J. J. Aklonis and R. Salovey, "Model Filled Polymers I. Synthesis of Crosslinked Monodisperse Polystyrene Beads," *J. Polym. Sci.: Part A: Polym. Chem.*, **28**, 1909-1921 (1990).

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3. D. Zou, J. J. Aklonis and R. Salovey, "Model Filled Polymers XI. Synthesis of Monodisperse Crosslinked Polymethacrylonitrile Beads," *J. Polym. Sci.: Polym. Chem.*, submitted (1991).

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