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STATE UNIV OF NEW YORK AT ALBANY RESEARCH FOUNDATION F/G 11/9  
PHYSICAL CHEMISTRY OF HIGH POLYMERS - SURFACE PROPERTIES OF INT--ETC(U)  
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PHYSICAL CHEMISTRY OF HIGH POLYMERS - SURFACE  
PROPERTIES OF INTERPENETRATING POLYMER NETWORKS.

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AD A101692

FINAL REPORT 1 Sep 1981

H. L. FRISCH

June 1, 1981

U. S. Army Research Office

Grant DAAG 29-77-G -0213

September 1, 1977 to February 1, 1981

RESEARCH FOUNDATION  
State University of New York

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER FINAL REPORT	2. GOVT ACCESSION NO. AD-A101642	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Physical Chemistry of High Polymers - Surface Properties of Interpenetrating Polymer Networks		5. TYPE OF REPORT & PERIOD COVERED Final - 9/1/77-2/1/81
7. AUTHOR(s) H.L. FRISCH		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS Research Foundation, State University of NY P. O. Box 9 Albany, N.Y. 12222		8. CONTRACT OR GRANT NUMBER(s) Grant No. DAAG 29 77 G 0213 1
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Research Office Post Office Box 12211 Research Triangle Park, NC 27709		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Department of the Army U.S. Army Research Office P.o. Box 12211 Research Triangle Park, NC 27709		12. REPORT DATE June 1, 1981
		13. NUMBER OF PAGES 5
		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report)  Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)  NA		
18. SUPPLEMENTARY NOTES The view, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Interpenetrating Polymer Networks, Adhesion, Surface Chemistry of Polymers, Diffusion in Polymers, Computer Simulation of Polymers, Glass fibers.		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) We have investigated the surface chemistry of interpenetrating polymer networks (IPN) as they relate to the development of a new class of improved, thermally stable adhesives with unusual surface and adhesive properties. We have carried out mechanical, thermal, wetting, permeability and electron microscopic investigations of polyurethane epoxy and polyacrylate IPN's. We have studied the minimum critical surface tension as a function of network composition, as		

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## 20. ABSTRACT CONTINUED

observed in polyurethane-epoxy IPN's and transport properties in such homogeneous and partially inhomogeneous polymers.

## Summary of Results:

We have synthesized novel classes of polyurethane-epoxy 1,2 (PU-EP) and polyurethane-acrylate 3 (PU-AC) interpenetrating polymer networks (IPN) and compared their thermal and morphological characteristics with a newly synthesized IPN composed of polystyrene and poly (2,6 - dimethyl - 1,4 phenylene oxide)(PS-PPO 2,4). The last is an ideally IPN since the component polymers form miscible blends. The domain sizes of the PU-EP IPN were not much larger than that of the PS-PPO IPN while the PU-AC showed larger domains and exhibited two inwardly shifted glass transition temperatures. The PU-EP IPN's had outstanding adhesive properties while the PU-AC IPN's are promising candidates for coatings, etc.

We have measured the advancing contact angles of drops of water methanol and methanol-ethylene glycol mixtures on films of polyurethane-epoxy interpenetrating polymer networks. The extrapolated critical surface tensions were in excellent agreement with each other. A sharp minimum is observed in the critical surface tension at network compositions where we have found maxima in ultimate mechanical properties. We advance a physical explanation based on unrelieved surface strains. We have also measured the toluene vapor transmission (permeability, diffusion and sorption coefficients) in these films. These results, together with the water vapor permeabilities, are in complete accord with the expected morphologies of these networks. A fuller discussion of how the morphological aspects and the minimum critical surface tension can be employed in adhesive technology is given in reference 5. The extent to which these characteristics are shared by IPN's made of polymers which form compatible polymer blends is reviewed extensively in reference 3. Recently our group has been joined by Dr. H. S. Xiao of the Organic Chemistry Institute of the Chinese People's Republic who has informed us of the application of PU-EP, similar to the ones prepared by us, for an optimal anti-cavitation turbine propeller coating.

Extensive theoretical investigations have been carried out on diffusional processes which underlie some of these experimental investigations. Specifically we studied the theory of diffusion in glassy<sup>6</sup> and inhomogeneous<sup>7,8,9</sup> (phase separated) systems. Jointly with Prof. S. A. Stern we have prepared a review of selective permeation of gases through polymers<sup>10</sup>. We have shown how SO<sub>2</sub> staining, used in our morphological investigations, affects the gas permeability of polymer films<sup>11</sup>.

We have begun the process of computer modelling on a molecular scale of bulk polymeric systems. The preliminary results can be found in reference 12 and are in substantial agreement with predictions of polymer scaling theories<sup>13</sup>. Ultimately we hope to study in this fashion the surfaces of idealized bulk polymers.

We have also investigated the basic physical processes which relate the adhesion of polymer coatings in strengthening glass fibers for optical communication<sup>14, 15</sup>.

## References

1. H. L. Frisch, J. Cifaratti, R. Palma, R. Schwartz, R. Foreman, H. Yoon, D. Klempner and K. C. Frisch, *Polymer Alloys* (ed. by D. Klempner and K.C. Frisch), Plenum Publishing Corp., NY, p. 97 (1977).
2. Frisch, Foreman and Schwartz, *Polymer Engineering & Science* 19, 294 (1979).
3. H. L. Frisch, K. C. Frisch and D. Klempner, *Pure and Applied Chemistry* (in press).
4. Frisch, Klempner, Yoon and Frisch, *Macromolecules* 13, 1016 (1980).
5. H. L. Frisch and K. C. Frisch, *Progress in Organic Coatings* 7, 105 (1979).
6. H. L. Frisch, *Polymer Engineering & Science* 20, #1, 2-13 (1980).
7. H. L. Frisch, *J. Phys. Chem.* 82, 1559 (1978).
8. R. A. Ludolph, W. R. Vieth and H. L. Frisch, *J. Phys. Chem.* 83, 2793 (1979).
9. H. L. Frisch, G. Forgacs and S. T. Chui, *J. Phys. Chem.* 83, 2787 (1979).
10. S. A. Stern, H. L. Frisch, *Annual Reviews of Materials Science* (in press).
11. H. Ghiradella, J. Cifaretti, R. Palma and H. L. Frisch, *J. Appl. Polymer Sci.* 23, 1583 (1979).
12. Frisch, Bishop, Ceperley and Kalos, *J. Macromolecular Sci. Phys. B* 18(3), 453-459 (1980).
13. P. G. de Gennes "Scaling Concepts in Polymer Physics", Cornell University Press, Ithaca, N.Y. 1978.
14. T. K. Kwei and H. L. Frisch, *Macromolecules* 11, 1267 (1978).
15. Schonhorn, Wang, Vazirani and Frisch, *J. Appl. Phys.* 49, 4783 (1978).

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List of Publications and Technical Reports under Sponsorship of this Grant:

A. Technical Reports:

Progress Reports: 9/1/77 to 2/1/78; 2/1/78 to 9/1/78; 9/1/78 to 6/30/79;  
7/1/79 to 1/31/80; 2/1/80 to 6/30/80.

B. Publications:

1. Barrier and Surface Properties of Polyurethane Epoxy Interpenetrating Polymer Networks I, H. L. Frisch, J. Cifaratti, R. Palma, R. Schwartz, R. Foreman, H. Yoon, D. Klemper and K. C. Frisch in Polymer Alloys (ed. by D. Klemper and K. C. Frisch), Plenum Publishing Corp., New York New York, p. 97 (1977).
2. Barrier and Surface Properties of Polyurethane-Epoxy Interpenetrating Polymer Networks, II, Frisch, Foreman and Schwartz, Polymer Engineering & Science 19, 294 (1979).
3. Permeation and Sorption in the Linear Laminated Medium, H. L. Frisch, J. Phys. Chem. 82, 1559 (1978).
4. Sorption and Transport in Glassy Polymers - A Review, by H. L. Frisch, Polymer Engineering & Science 20, #1, 2-13 (1980).
5. Time Moments Analysis of Sorption and Permeation in Linear Laminated Media, H. L. Frisch, G. Forgacs and S. T. Chui, J. Phys. Chem. 83, 2787 (1979).
6. Change in Water Vapor Permeability of Polymer Films Treated with Osmium Tetroxide, H. Ghiradella, J. Cifaretti, R. Palma and H. L. Frisch, J. Appl. Polymer Sci. 23, 1583 (1979).
7. Effects of Linear Reaction and Sorption Processes on the Penetrant Time Lag, R. A. Ludolph, W. R. Vieth and H. L. Frisch, J. Phys. Chem. 83, 2793 (1979).
8. Computer Simulation of Chains in Solution and Bulk State, Frisch, Bishop, Ceperley and Kalos, J. Macromolecular Sci., Phys. B. 18(3), 453-459 (1980).
9. Relationship Between Fiber Tension and Drawing Velocity and their Influence on the Ultimate Strength of Laser-Drawn Silica Fibers, H. Schonhorn, H.N. Vazirani, and H. L. Frisch, J. Appl. Phys. 49, 3703 (1978).
10. Static and Dynamic Fatigue of High-Strength Glass Fibers Coated with a UV-Curable Epoxy-Acrylate, Schonhorn, Wang, Vazirani and Frisch, J. Appl. Phys., 49, 4783 (1978).
11. Poly (2,6-Dimethyl - 1,4-Phenylene Oxide) - Polystyrene Interpenetrating Polymer Networks, Frisch, Klemper, Yoon and Frisch, Macromolecules 13, 1016 (1980).
12. Advances in Interpenetrating Polymer Networks, H. L. Frisch, K. C. Frisch and D.Klemper, Pure and Applied Chemistry (in press).
13. Polyurethane-Epoxy Interpenetrating Polymer Networks--Barrier and Surface Properties, H. L. Frisch and K. C. Frisch, Progress in Organic Coatings 7, 105 (1979).

14. The Selective Permeation of Gases Through Polymers, S. A. Stern, H. L. Frisch, Annual Reviews of Materials Science (in press).

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