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In Memory of Prof. Robert Simha (1912-2008)

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In Memory of Prof. Robert Simha (1912–2008)

This issue of Polymer Engineering and Science includes papers from the *International Symposium on Polymer Physics*, held October 17–18, 2007 at the National Research Council Canada in Boucherville, Quebec, on the occasion of Prof. Robert Simha's 95th birthday. Sadly, Prof. Simha passed away eight months after the Symposium and we dedicate this issue to his 75 year long research odyssey, encompassing the hydrodynamics of suspensions and solutions, statistics of macromolecules, and the thermodynamics of molten and glassy polymers. The photograph was taken during his Symposium presentation.

Robert Simha was born in Vienna, Austria, in 1912. After finishing Realgymnasium, Robert entered the University of Vienna, obtaining his doctorate in 1937 with the attribute "excellent". His advisors in the Institute of Theoretical Physics were Hans Thirring and Felix Ehrenhaft, good friends of Albert Einstein. Thirring steered Robert to the First Chemical Institute, chaired by Herman Mark, who had established three areas of research: rubber elasticity, kinetics of free radical polymerization, and the viscosity of suspensions and solutions. It was suggested to Simha, to extend the Einstein theory of suspension viscosity to particles with non-spherical shape (*e.g.*, ellipsoids or flexible coils), and to higher concentrations. In his thesis, he successfully tackled the latter problem by considering the binary hydrodynamic interactions. During three subsequent postdoctoral years in Mark's Institute, Simha validated Einstein's equation for parabolic Poiseuille flow and made "excursions" (with Fritz Eirich) into kinetic theory, as well as viscosity, surface tension and heats of vaporization of chain molecular fluids. The Mark Institute was dissolved in 1938 and Robert left for the USA.

Robert joined Columbia University where, as a research associate, he worked to extend Einstein's viscosity theory to ellipsoidal solutes and on a general kinetic theory of chain degradation (with E. Montroll). He also taught a graduate course on chemical kinetics at Brooklyn College (now City University). In 1941, he joined Herman Mark at the Brooklyn Polytechnic Institute, but within a year assumed a faculty position at Howard University in Washington, DC, and then, in 1945, joined the National Bureau of Standards, NBS (now NIST) as a

consultant and Coordinator of Polymer Research. During his six years at NBS, Simha worked with Leo Wall on the quantitative theory of depolymerization, which was experimentally confirmed by Sam Madorsky. Next, he assumed a faculty position at New York University, where he taught a graduate course on transport processes and conducted research on the statistical thermodynamics of the liquid state and on the viscosity of polymer solutions in good and poor solvents. There, Robert made another excursion into the hydrodynamics of suspensions, publishing in 1952 a highly successful viscosity-concentration relation based on a cell model of intermolecular interactions that was valid over the entire range from the Einstein limit to close packing.

In 1958, Simha moved to the University of Southern California (USC), where he became very active in professional scientific organizations. He was head of the ACS Polymer Group, organizer and chairman of the winter Gordon Research Conference, and organized a series of seminars and summer courses. Among his distinguished speakers were Peter Debye and Linus Pauling. In 1961, Leszek Utracki joined Robert to work on the concentration, solvent quality and chain stiffness dependence of solution viscosity; this began a collaboration that lasted 47 years. Also at USC, Robert worked with Ray Boyer on the equilibrium and non-equilibrium properties of polymer melts and glasses, general correlations between the glass transition temperature, T_g , and the ther-

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mal expansivity at T_g . This was followed by a series of explorations of sub-glass relaxations with Bob Haldon. Undoubtedly, his most significant development at USC was the derivation of the cell-hole theory of liquids, started with V.S. Nanda and ultimately completed with T. Somcynsky. The theory for spherical and chain molecule liquids not only correctly described the temperature and pressure effects on specific volume (PVT), but also that of the hole fraction, *i.e.*, the free volume content.

In 1968, Robert joined the faculty of the Department of Macromolecular Science and Engineering at Case Western Reserve University (CWRU), where he remained as Emeritus Professor until his death on June 5, 2008. At CWRU, his collaboration with A. Silberberg focused on the kinetics of cooperative processes in synthetic and biological macromolecular structures. He and his student Robert Lacombe showed that the kinetic questions could be answered by detailed balancing of opposing rates, which described a spectrum of linear structures, chain lengths and sequential distributions of co-monomers. His other major research topic continued to be properties of the condensed polymeric state. He and A. Quach constructed a pressure dilatometer, performed careful PVT measurements on two polymer melts, and compared the results with the prediction of cell-hole theory, demonstrating for the first time quantitative agreement. The results stimulated similar research at CWRU and in other laboratories, extending that original success to over 50 polymers and mixtures. In that area, Robert had wide-ranging international collaborations, including R. K. Jain (India) extending the hole-cell theory to multicomponent systems, E. Nies and A. Stroeks (The Netherlands) on phase equilibria, H. Xie (China) and C. B. Park (Canada) on gas solubility, L. A. Utracki (Canada) on molten and glassy multiphase polymers, including nanocomposites.

Another aspect of Simha's activities involved a semi-theoretical approach to non-equilibrium properties through the use of the computed hole fraction. With J. McKinney (NBS), Robert showed that upon cooling the free volume partially freezes at T_g , and with L. A. Utracki the connection of the hole fraction/free volume with viscous flow was demonstrated. Various links between free volume and positronium annihilation lifetime spectroscopy (PALS) were studied with Profs. J. McGervey, A. M. Jamieson, G. Consolati and F. H. Maurer. A further extension consisted of a theory of elastic constants of polymer glasses by E. Papazoglou, which involved the stress dependence of free volume. Finally, there was also analysis of the dynamics of volume relaxation, or physical aging, with J. G. Curro and R. E. Robertson, treated as a dynamics of free volume states, where the connection between the two volume quantities was provided by the hole theory.

Up to the last day of his life Robert Simha was an active and cherished member of the polymer physics community, enlivening scientific discussions and social events with his wry sense of humor. His keen scientific insights and historical perspectives of the development of the field of polymer science made him a valuable resource for students and colleagues alike. His manifold contributions are bedrocks for further progress in polymer science.

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Montreal, Canada, October 2008.