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Frontal photopolymerization and applications in complex fabrication JOAO CABRAL, STEVEN D. HUDSON, CHRISTOPHER HARRISON, JACK DOUGLAS, Polymers Division, NIST — The exposure of a photopolymerizable liquid to light may leads to a propagating wavefront of network formation that invades the unpolymerized material from the illuminated surface. We theoretically describe this light-driven frontal photo-polymerization (FPP) process, which is the basis of many commercially important fabrication methods, in terms an order parameter phi(x,t) characterizing the extent of monomer-to-polymer conversion, the temporally and spatially evolving optical attenuation T(x,t) of the medium, and the height h(t) of the resulting solidified material. The non-trivial aspects of this frontal polymerization process derive from the coupling of miu(x,t) and the growing non-uniform network h(x,t) and we consider limiting situations in which the optical attenuation increases ('photodarkening') or decreases ('photobleaching') in time. Since FPP fabrication of complex three-dimensional structures containing components having different material characteristics would greatly extend the practical utility of this method, we explore the influence of nanoparticle (silica, titania, and multi-wall carbon nanotube) additives on FPP front propagation. We also characterize the influence of temperature on the kinetics of FPP since this factor can often be controlled in practice. Our results are utilized in the fabrication of complex structures and in particular, of microfluidic masters and devices.

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