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Suppressed beta relaxations and reduced heat capacity in ultrastable organic glasses prepared by physical vapor deposition

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Glasses play an important role in technology as a result of their macroscopic homogeneity (e.g., the clarity of window glass) and our ability to tune properties through composition changes. A problem with liquid-cooled glasses is that they exhibit marginal kinetic stability and slowly evolve towards lower energy glasses and crystalline states. In contrast, we have shown that physical vapor deposition can prepare glasses with very high kinetic stability. These materials have properties expected for "million-year-old" glasses, including high density, low enthalpy, and high mechanical moduli. We have used nanocalorimetry to show that these high stability glasses have lower heat capacities than liquid-cooled glasses for a number of molecular systems. Dielectric relaxation has been used to show that the beta relaxation can be suppressed by nearly a factor of four in vapor-deposited toluene glasses, indicating a very tight packing environment. Consistent with this view, computer simulations of high stability glasses indicate reduced Debye-Waller factors. These high stability materials raise interesting questions about the limiting properties of amorphous packing arrangements.