Recycling HPLC methods have been used to prepare relatively pure samples of the most abundant C₈₄ isomers: D₂(IV) and D₂d(II). Transient absorption studies were then performed on these samples to compare their photophysical properties. When dissolved in rigid films of PMMA to suppress bimolecular decay processes, the D₂(IV) isomer showed a triplet state lifetime of 680 µs at 297 K. This is the second-longest triplet lifetime found to date for any pristine fullerene (shorter only than C₇₀’s). The induced absorption spectrum of D₂(IV) C₈₄ shows a Tₐ→T₁ absorption peak near 520 nm. Analysis of variable-temperature triplet kinetic data measured between 77 and 320 K reveals that the D₂(IV) triplet state has two thermally activated decay channels with activation energies near 300 and 2360 cm⁻¹. These probably reflect T₁ decay mechanisms involving vibrational and electronic excitations, respectively. The triplet state relaxation of the D₂d(II) isomer of C₈₄ is dramatically different. Its intrinsic lifetime at 297 K is approximately 5 µs (a factor of 100 below that of the D₂(IV) isomer), and its transient spectrum shows a peak near 540 nm. In addition, T₁ decay of the D₂d(II) isomer depends only weakly on temperature over the studied range. Further comparative results on molar absorptivities, singlet oxygen sensitization, and fluorescence will also be presented.