The vinyl radical has been trapped in $^4$He nanodroplets and probed with infrared laser spectroscopy in the CH stretch region between 2850 and 3200 cm$^{-1}$. The assigned band origins for the CH$_2$ symmetric ($\nu_3$), CH$_2$ antisymmetric ($\nu_2$), and lone $\alpha$-CH stretch ($\nu_1$) vibrations are in good agreement with previously reported full-dimensional vibrational configuration interaction calculations.$^a$ For all three bands, $a$-type and $b$-type transitions are observed from the lowest symmetry allowed rovibrational state of each nuclear spin isomer, which allows for a determination of the tunneling splittings in both the ground and excited vibrational levels. Comparisons to gas phase millimeter-wave rotation-tunneling$^b$ and high-resolution jet-cooled infrared spectra$^c$ reveal that the effect of the $^4$He solvent is to reduce the ground and $\nu_3$ excited state tunneling splittings by $\approx20\%$. This solvent-induced modification of the tunneling dynamics can be reasonably accounted for by assuming either an $\approx2.5\%$ increase in the effective barrier height along the tunneling coordinate or an $\approx5\%$ increase in the effective reduced mass of the tunneling particles.