MILLIMETER DETECTION OF AlO (X^2Σ^+): METAL OXIDE CHEMISTRY IN THE ENVELOPE OF VY CANIS MAJORIS

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A new circumstellar molecule, the radical AlO (X^2Σ^+), has been detected toward the envelope of the oxygen-rich supergiant star VY Canis Majoris (VY CMa) using the Arizona Radio Observatory (ARO). The N = 7 → 6 and 6 → 5 rotational transitions of AlO at 268 and 230 GHz were observed at 1 mm using the ARO Submillimeter Telescope (SMT) and the N = 4 → 3 line was detected at 2 mm using the ARO 12 m. Based on the shape of the line profiles, AlO most likely arises from the dust-forming region in the spherical outflow of VY CMa, as opposed to the blue- or red-shifted winds, with a source size of \( \theta_s \sim 0.5'' \). Given this source size, the column density of AlO was found to be \( N_{\text{mol}} \sim 2 \times 10^{15} \) cm\(^{-2}\) for \( T_{\text{rot}} \sim 230 \) K, with a fractional abundance, relative to H\(_2\), of \( \sim 10^{-8} \). Gas-phase thermodynamic equilibrium chemistry is the likely formation mechanism for AlO in VY CMa, but shocks may disrupt the condensation process into Al\(_2\)O\(_3\), allowing AlO to survive to a radius of \( \sim 20 \) R\(_*\). The detection of AlO in VY CMa is additional evidence of an active gas-phase refractory chemistry in oxygen-rich envelopes, and suggests such objects may be fruitful sources for other new oxide identifications.