# An observational study of dust nucleation in Mira (o Ceti). I. Variable features of AlO and other Al-bearing species



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Context: Dust is efficiently produced by cool giant stars, but the condensation of inorganic dust is poorly understood. Observations of key aluminum bearing molecules around evolved stars has enabled us to investigate the nucleation of alumina (Al 2 O 3 ) dust in the gas. Aims: We aim to identify and characterize aluminum bearing species in the circumstellar gas of Mira (o Ceti) in order to elucidate their role in the production of Al 2 O 3 dust. Methods: We used multiepoch spectral line observations at (sub-)millimeter, far-infrared, and optical wavelengths including: maps with ALMA that probe the gas distribution in the immediate vicinity of the star at 30 mas; observations with ALMA, APEX, and Herschel in 2013-2015 for studying cycle and inter-cycle variability of the rotational lines of Al-bearing molecules; optical records as far back as 1965 to examine variations in electronic transitions over time spans of days to decades; and velocity measurements and excitation analysis of the spectral features that constrain the physical parameters of the gas. Results: Three diatomic molecules AlO, AlOH, and AlH, and atomic Al i are the main observable aluminum species in Mira, although a significant fraction of aluminum might reside in other species that have not yet been identified. Strong irregular variability in the (sub-)millimeter and optical features of AlO (possibly the direct precursor of Al 2 O 3 ) indicates substantial changes in the excitation conditions, or varying abundance that is likely related to shocks in the star. The inhomogeneous distribution of AlO might influence the spatial and temporal characteristics of dust production. Conclusions: We are unable to quantitatively trace aluminum depletion from the gas, but the rich observational material constrains time-dependent chemical networks. Future improvements should include spectroscopic characterization of higher aluminum oxides, coordinated observations of dust and gas species at different variability phases, and tools to derive abundances in shock-excited gas. The ALMA data, including spectral cubes, moment-zero maps, and spectra, are only available at the CDS via anonymous ftp toă http://cdsarc.u-strasbg.fr ( http://130.79.128.5 ) or viaă http://cdsarc.u-strasbg.fr/viz-bin/qcat?J/A+A/592/A42
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