Dust formation and wind acceleration around Al_2O_3 dust-rich AGB stars

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Formation of dust grains around an asymptotic giant branch (AGB) stars is a trigger for generation of the stellar wind, which supplies freshly synthesized nuclides to the Galaxy. Silicate is the dominant dust species in space, but ~40% of oxygen-rich AGB stars are thought to have comparable amounts of alumina (Al_2O_3) dust [1]. Mid-infrared spectroscopic observations indicate that crystalline and amorphous or metastable alumina coexist around such alumina-rich AGB stars [1, 2]. The crystalline alumina (corundum or α-Al_2O_3) can form either by direct condensation from gas molecules or crystallization of amorphous or metastable alumina.

Alumina grains formed around evolved stars (presolar alumina grains) have been identified from primitive chondrites [e.g., 3] on the basis of their highly anomalous oxygen isotopic compositions. The systematic analysis of presolar alumina grains combining FE-SEM, EBSD, NanoSIMS, and TEM showed variety of their mineralogical characteristics. An presolar corundum grain identified from an acid residue of QUE 97008 (LL3.05) had developed rhombohedral {011} faces. The subhedral shape and micron size of this grain indicate that it formed by direct condensation and growth in an extended atmosphere around an oxygen-rich AGB star [4].

Distributions of circumstellar gas molecules forming dust grains provide complementary information for probing the circumstellar dust formation. Our recent observations with Atacama Large Millimeter/submillimeter Array (ALMA) showed the spatial distributions of AlO and ^{29}SiO molecules around an alumina-rich M-type AGB star, W Hya [5]. AlO molecules were only observed within three stellar radii (R_{star}), whereas ^{29}SiO was distributed in the accelerated wind beyond 5 R_{star} without significant depletion. This strongly suggests that condensed alumina dust plays a key role in accelerating the stellar wind and in preventing the efficient formation of silicate dust around W Hya.

These observations of presolar alumina grains and alumina-forming gas suggest micron sized alumina formation is a key for understanding the dust formation and acceleration of the stellar winds around oxygen-rich AGB stars.

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