Challenging the Identification of Silicon Nitride Dust in Extreme Carbon Stars

Karly M. Pitman* Anne M. Hofmeister* Angela K. Speck†

February 3, 2006

Abstract

It has been well established that SiC is a dominant mineral in the condensation sequence of carbon-rich stars (or C-stars). The presence of other mineral species in interstellar dust surrounding C-stars may be indicative of exotic formation conditions for these objects. Observers have long held out hope for detecting the compound silicon nitride (Si_3N_4) in stellar spectra; however, previous attempts to identify Si_3N_4 in dust material around novae, planetary nebulae, and late-type binary and C-stars have proved to be unsuccessful (Clément et al. 2005, ApJ, 821, 985 and references therein). Clément et al. (2005) suggested that a broad, double-peaked 9-11 μm absorption feature in the ISO SWS spectra of two extreme C-stars (AFGL 2477 and AFGL 5625) is due to Si_3N_4. This assignment was based on the correlation of several weak observational spectral features with laboratory spectral features of α-Si_3N_4 in the 15-30 μm range. The broad 9-11 μm feature had been previously attributed to a mixture of SiC and interstellar silicate (Speck et al. 1997, MNRAS, 20, 431), and more recently to amorphous SiC (Speck et al. 2005, ApJ, 634, 426). We dispute the Si_3N_4 assignment on the basis of expected interstellar abundances, Si_3N_4 meteoritic isotope studies, blackbody correction methods, and spectral peak assignment as compared to noise. Speck et al. (2005) discovered another extreme carbon star (IRAS 00210+6221) that exhibits a 9-11 μm absorption feature identical to those found in AFGL 2477 and AFGL 5625. A preliminary re-analysis of the spectra of these three extreme carbon star spectra has revealed that neither AFGL 2477 nor IRAS 00210+6221 display any of the 15-30 μm features. For AFGL 5625, any features present in this range are at $> 2\sigma$ level, and therefore may just be noise. We compare the observational spectra to independently acquired laboratory spectra for Si_3N_4, as well as other nitride minerals consistent with recently published condensation sequences (e.g., AlN, TiN), carbides, and silicides. Our thin film laboratory absorbance spectra of α- and β-Si_3N_4 appear to give good agreement with the KBr pellet method transmission spectra of Clément et al. (2005). Based on

*Washington University - St. Louis
†University of Missouri - Columbia

these analyses, we conclude that a unique identification of Si_3N_4 has not yet been made and calculate an upper limit to the abundance based on a non-detection.

This work is supported through NASA APRA04-000-0041.