SIZES OF CARBON GRAINS CONDENSING IN SNII SHELLS.

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Introduction: Low-density graphite grains recovered from primitive meteorites most likely condensed in the outflows from the explosions of massive stars (SNII) [1]. A chemical model for the synthesis of such grains considers production via linear carbon chains, which we denote C_n for a chain containing *n* atoms. In the model, chains grow by capture of carbon atoms and are destroyed by oxidation and photodisintegration [2-6]. Grains form when a chain (taken to be C_8) isomerizes to form a ring (called C_{8r}), which is then stable against further oxidation and serves as a grain seed. The model allows for carbon grain growth in matter with O > C (as is the case in the inner shells of the expanding supernova) if radioactive ^{56}Co is present. Decay of ^{56}Co emits gamma rays, which Compton upscatter electrons. Those fast electrons hinder the growth of CO, which would otherwise lock up all carbon and prevent carbon dust production [2].

We previously studied this chemical model with detailed network calculations [7], but those calculations left C_{8r} inert. As a consequence, we were able to estimate possible grain sizes but were not able to compute the grain size spectrum. Previously we have used network binning to study large grain growth [4]. Such binning is fairly accurate, but it assumes a steady-state abundance distribution within each bin. In this work, we instead follow discrete grains coupled to the underlying carbon chain network. This allows us to compute the grain size spectrum and the spectrum of grain formation times within the calculation.

Calculations: For our calculations, we use the network of [7] to compute the abundance of C_8. We consider a co-moving volume with a fixed number of total atoms. Once the total abundance of C_8 in the co-moving volume becomes sufficiently large that the isomerization rate leads to a C_{8r} number greater than unity, we create a C_{8r} seed molecule and correspondingly decrease the network abundance of C_8. Henceforth in the calculation, we couple C atom captures on that seed molecule in the network; thus, when that seed molecule captures free C, the C abundance decreases. As the calculation continues, when the next C_8 molecule isomerizes, we add it to the collection of grains, record its formation time, and allow it to capture C atoms as well. Once the calculation finishes, we use information in the grain collection to compute the spectrum of grain sizes.

Results: The spectrum of grain sizes depends on the details of the competition between seed molecule formation and free C atom depletion by capture onto the growing grains. Larger (and fewer) grains grow when seed molecule formation is hindered (for example, by enhanced oxidation of carbon chains). Also, for other parameters remaining the same, increasing capture rates of C onto large grains depletes C more quickly and reduces late seed production. This also results in fewer (and larger) grains forming. For reasonable estimates of cross sections for carbon capture onto grains, we find for certain supernova shell conditions that the model is able to produce graphite grains with sizes as large as $\sim 10^{15}$ atoms.

References: [1] Jadhav M. et al. 2006, *New Astron. Rev.* 50:591-595. [2] Clayton D. et al. 1999, *Science* 283:1290-1292. [3] Clayton D. et al. 2001, *Astrophys. J.* 562:480-493. [4] Deneault E. A. N. et al. 2006, *Astrophys. J.* 638:234-240. [5] Cherchneff I. and Dwek E. 2009, *Astrophys. J.* 703:642-661. [6] Cherchneff I. and Dwek E. 2010, *Astrophys. J.* 713:1-24. [7] Yu. T. et al. 2013, *Astrophys. J.* 769:38.