ARE ALL THE METEORITIC NANODIAMONDS PRESOLAR ? Galina K. Ustinova , Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, Moscow V-334, 119991 Russia; E-mail: ustinova@dubna.net.ru

Presolar relics: The galactic molecular clouds are formed under the ejections of the evolving stars and supernova explosions, and they consist of a mixture of gas, mainly, molecular hydrogen, and interstellar dust being a mixture of the matter of various stellar sources. In particular, the base of the protosolar matter was that of a giant gas-dust nebula, which, during ~ 10 My of its existence before the collapse to protosun, was uniformly mixed by supersound turbulence with the products of nucleosynthesis of about ten supernovae [1]. Nevertheless, the protoplanetary nebula was not uniform in its physical and chemical conditions, so that the grains of the presolar dust are not representative samples in the bulk composition of it [2,3]. Their content in the primitive chondrites is extremely small: for the most abundant grains of the presolar diamond it is ~1400 ppm on the average; for those of silicon carbide (SiC) ~14 ppm, for those of graphite ~10 ppm, [2]. The supposition of the presolar nature of these grains is based on the specific isotopic anomalies, conditioned by the peculiarities of the isotopic compositions of their stellar sources. However, there is not still a single opinion on the origin of the most abundant grains of presolar diamond in chondrites [4,5, et al.].

Presolar diamond: The median value of the meteorite diamond size is ~ 3 nm (that is 10-1000 times less than for other presolar grains), which does not allow us to study the individual grains and derive information on the mechanism of their formation. On the other hand, the laboratory experiments on synthesis of artificial nanodiamonds demonstrate an extremely large spectrum of the physical and chemical conditions for realization of this process. Indeed, the synthetic nanodiamonds are obtained in the processes of detonation synthesis at high pressure and temperature (ultradispersed nanodiamond, or UDD), as well as by low-pressure condensation being similar to chemical vapor deposition at moderate temperatures (CVD-techniques which are used for the epitaxial growth of ultra nanocrystalline diamond films, or UNCD), as well as by irradiation of carbonaceous materials with laser, intensive ultraviolet radiation (UV) or high energy particles [6]. In view of the variety of the admissible astrophysical conditions one may anticipate ubiquitous distributions of nanodiamonds in cosmos. Thus, the observations of the interstellar extinction testify to the fact that up to 10% of the interstellar carbon could be bound up in the interstellar diamond [7]. Nanodiamonds with the lognormal size distribution being similar to that for meteoritic ones are observed in circumstellar disks in the systems of Herbig emission stars of HD97048 and Elias 1 [8]. Laboratory experiments show also that diamond nucleation is possible due to UV photolysis of the interstellar icy mixtures (H_2O, CO, NH_3, and CH4) in the molecular clouds [9]. A number of mechanisms of the nanodiamond generation in supernova is proposed: by low-pressure condensation (similar to CVD-process) in the expanding gas envelopes [10]; by shock metamorphism of graphite or grains of amorphous carbon due to high energy collisions of grains in the interstellar shock waves [11]; by etching graphite particles with the intensive UV radiation of the type II supernova (SNII) [12]; by transformation of the carbon grains under irradiation with high-energy ions [13]; etc. The ample opportunities of the nanodiamond synthesis in cosmos testify to the existence of several populations of the nanodiamond grains, differing in their structure conditioned by the mechanism of their genesis [5], as well as, in their isotopic composition being an indicator of their astrophysical sources. In this connection, the population of nanodiamond grains, containing the anomalous Xe-*HL*, the isotopic relations of which could indicate to the enrichment by the products of *p*- and *r*- processes at the supernova SnII explosion (whereas the C isotope relations are practically solar) attracts the greatest attention [10, 14].

Noble gases: The isotopic compositions of noble gases also can reflect the sources of their origin. About 4% of individual grains of the main population of SiC are carriers of the anomalous component Ne-*E(H)*, consisting practically from pure ^{22}Ne, which could be produced in the He shell of the AGB-stars. Rare grains of the presolar graphite are carriers of the anomalous component Ne-*E(L)*, consisting also from practically pure ^{22}Ne, which could be produced by *in situ* decay of the radioactive ^{22}Na at the nova explosions [14]. The anomalous Xe-*HL* component (as well as He-*HL*, Ne-*HL*, Ar-*HL* and Kr-*HL*), side by side with the noble gases of the solar compositions, is observed only in the nanodiamond grains, pointing out to their origin at the supernova explosions [10, 14].

The main problem consists in the following question: how were the gases embedded into the presolar grains? The natural processes – capture/trapping and implantation – are constrained with the generation mechanisms of the presolar grains themselves. Since the Xe-*HL* component is observed only in the meteoritic nanodiamonds and it is absent in the other presolar relics, it is natural to suppose that this component was formed under the same conditions, in which the nanodiamond was synthesized. The most consistent mechanism of that process is the formation and capture of the anomalous Xe-*HL* component simultaneously with the nanodiamond synthesis in the conditions of the shock wave propagation from the supernova explosions [15]. The synthesis of a nanodiamond and its enrichment with Xe-*HL* are possible in the extreme *PT*-conditions at the prefront of the shock wave, as well as by nucleation in the range of rarefaction behind the front of the shock wave, as well as by irradiation of carbonaceous grains with high-energy particles. The anomalous isotopic composition of the Xe-*HL* is conditioned by amplifying the rigidity of the energy spectrum of nuclear active particles and enrichment of the spectrum with heavier ions under their acceleration in shock waves [16].

The following question is of equal importance as well: how could the noble gases be preserved in the presolar grains that survived in the extreme *PT*-conditions of collapse of the protosolar nebulae into the protosun? It was shown earlier [17] by studying the genesis of the anomalous Ne-*E* components that the observable content ranges of Ne-*E(H)* in SiC (2060-35800) 10^{-8} cc/g and Ne-*E(L)* in graphite spherules (4240-14000) 10^{-8} cc/g in the Murchison chondrite [18, 19], most likely, were formed by nuclear-active particles accelerated at the front of the giant shock wave from the explosion of the last supernova. The presolar grains had to lose inevitably the thermonuclear and radiogenic ^{22}Ne of all the previous generations, as well as ^{21}Ne of the presolar irradiation of those grains, because the temperatures of some local processes in the collapsing protosolar nebula could exceed 1500-2000 K [20]. Analogously, one may expect that the presolar nanodiamond also lost, probably, the noble gases of all the previous generations, and the observable nanodiamond population containing the anomalous Xe-*HL* component had to be generated during the propagation of the giant shock wave from the last supernova explosion [15]. According to the data of [16], the last supernova before the formation of the solar system was a carbon detonation supernova (SnI). It is shown in [21] that there were appreciably more SnI formation at the time of the Solar system formation than today and that the conditions at origin of SnI in the binary carbon star system could be considered as the most favorable ones for synthesis of nanodiamonds with the almost solar isotopic composition. However, the ***r***-process is absent in the SnI explosion, so that Xe-H could be formed only at the front of the SnI explosive shock wave from the ambient Xe isotopes in the collapsing protosolar nebula, which had been synthesized in the earlier SnII explosions. This conception is in accordance with the results of the interplanetary dust study [22] showing that the nanodiamonds are absent in the dust of comets or/and their abundance decreases with the increase of the heliocentric distance. Such a picture is also in accordance with the observations of nanodiamonds in the vicinity of some evolving stars with accreting discs [8]. On the whole, it allows us to get associated with [22] and question whether all the nanodiamond grains are presolar.

Summary: The protosolar nebula contained nanodiamonds and Xe isotopes generated in several SnII explosions. At the last SnI explosion before the Solar system formation, all the grains had lost their noble gases of previous generation. In the conditions of the SnI explosive shock wave propagation, the newly generated nanodiamonds captured the Xe isotopes produced by the shock wave accelerated nuclear-active particles of very hard energy spectrum (spectral index $\gamma \sim 1$) and, in addition, some heaviest Xe isotopes, with which the front of the explosive shock wave was enriched in comparison with the surrounding medium.

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