

SEPARATION OF ALLENDE NANODIAMONDS BY ELECTROPHORESIS. O. Pravdivtseva¹, E. A. Shatoff^{1,2}, A. Meshik² and R. M. Stroud³, ¹Laboratory for Space Sciences and Physics Department, Washington University, CB1105, One Brookings Drive, Saint Louis, MO 63130, ²Physics Department, Brandeis University, MB 3096, 415 South Street, Waltham, MA 02453, ³Naval Research Laboratory, Code 6366, 4555 Overlook Ave. SW, Washington, DC 20375, (olga@physics.wustl.edu).

Introduction: The origin of meteoritic nanodiamonds remains an enigma after more than a quarter century since their discovery [1]. Even more puzzling is a highly anomalous xenon isotope component, Xe-HL, associated with them. Scanning transmission electron microscopy study has demonstrated that meteoritic nanodiamond residues also contain a sp^2 carbon phase resembling glassy carbon [2], suggesting that Xe-HL could be carried by the nanodiamonds, by the glassy carbon, or by both. Any ability to further purify nanodiamond residues, or separate nanodiamonds by size, surface properties/coating or charge could be advantageous. Previous experiments on Allende nanodiamonds have demonstrated that it is possible to manipulate them using electrophoresis, since nanodiamonds are mostly negatively charged [3]. A recent study of Allende nanodiamonds [4] suggested the presence of two sub-populations based on the concentrations of Xe-HL in aliquots of the liquid sampled from 12 sections of the electrophoresis column. Here we present the results of an electrophoresis experiment designed to improve the separation of these two sub-populations of diamonds.

Experimental: A nanodiamond separate was isolated from Allende following a slightly modified classical protocol [5]. Although we did not study the purity of our separate, it was shown previously that this procedure, in the case of Allende, yields samples with <1% elements of atomic number $Z > 6$, with SiC being the principal impurity (600 ppm) [6].

The electrophoresis was carried out inside an 18-cm length of Teflon tubing 2.46 mm in ID. The tube was filled with pure isopropanol; 12 μ l of nanodiamond solution were introduced at the negative electrode. Both ends of the tube were plugged with 99.99% Au electrodes to reduce the number of ions in the solution and, thus, keep the conductivity of the solution low, preventing it from overheating and evaporating. The ends of the tube were further sealed with glue.

In our previous experiment (Figure 1a) the cumulative amount of Xe-HL recovered from the column after 1 hour of electrophoresis corresponded to $\sim 2/3$ of the nanodiamonds introduced at the beginning [4]. It is most likely that the missing 1/3 of the nanodiamonds precipitated out of the solution and

deposited onto one of the gold electrodes. To verify this hypothesis, and to potentially better separate two sub-populations of nanodiamonds, we ran this experiment for half the time, to “slow down” the movement of particles along the electrophoresis column.

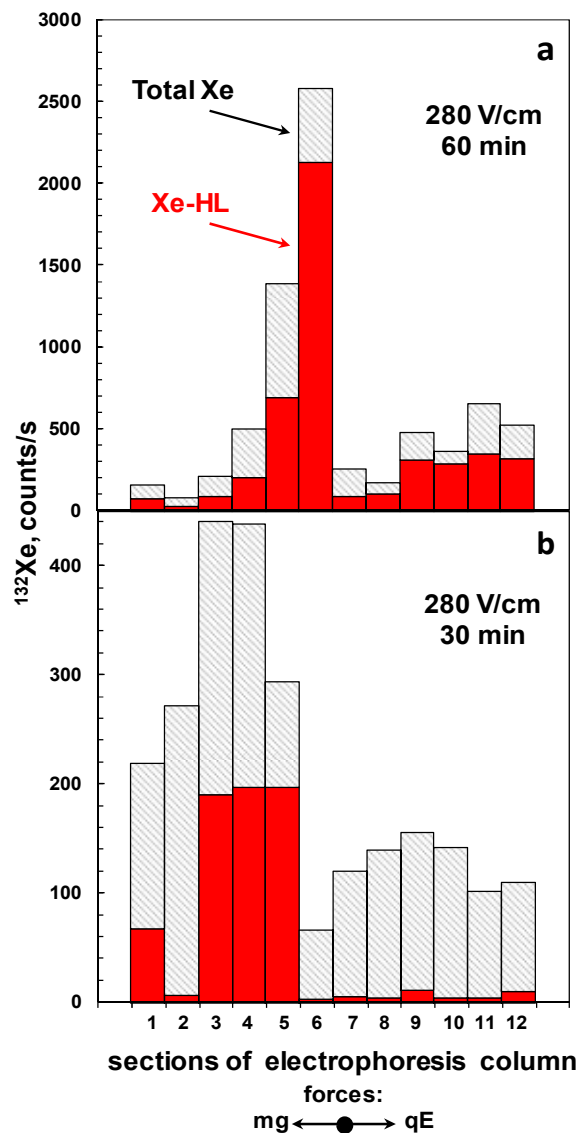


Figure 1. Distribution of total Xe and Xe-HL along the electrophoresis column after two experimental runs at different durations.

After 30 minutes the electrophoresis was stopped, and a series of clamps, each 1.5 centimeters apart, was applied to the tubing, dividing it into twelve sections. An aliquot of the liquid was taken from each section by micropipette and allowed to evaporate in small platinum boats. Sealed Pt-boats containing diamond residues were loaded into the vacuum sample system and held at 120°C for several days to remove surface contamination. Samples were melted in a single step at the melting point of Pt (~1768 °C), purified from chemically active components by sequential exposure of released gases to three SEAS getters. Heavy noble gasses were separated from He, Ne, and Ar using activated charcoal at -95°C and analyzed in the mass-spectrometer Supergnome-S with sensitivity of 7×10^{-16} cm³ STP/Hz. Measured xenon consisted mostly of Xe-HL with minor contribution from Xe-P3 and atmospheric Xe [7].

Results: The distribution of Xe-HL recovered from the electrophoresis column is shown in Figure 1b. In both experiments, the previous one [Fig. 1a] and the one reported here, about 12 μL of nanodiamond residue solution was introduced into the electrophoresis column. Contrary to our expectations, in this experiment we recovered about 6 times less Xe-HL than in the previous run. The distribution of Xe-HL measured during the previous experiment is characterized by two distinct peaks. The first peak is sharp, with most of the Xe-HL carrier material concentrated in section #6 of the electrophoresis column; the second peak is flat with a more uniform distribution of Xe-HL.

In our experiment, the first peak on the Xe-HL distribution plot is flat; the concentrations of Xe-HL observed in sections #3, #4, and #5 of the electrophoresis column are compatible with the concentrations observed in second peak of the previous experiment. It seems that our current run was too short. It allowed us to observe and recover the small population of fast moving particles. Apparently the material represented by the sharp peak in the previous experiment did not have time to move along the electrophoresis column. Most probably this material settled on the Au electrode after the experiment was stopped.

Conclusion: Based on the distribution of Xe-HL, recovered from 12 sections of the electrophoresis column in our last two experiments, the Allende nanodiamond separate apparently consists of at least 3 sub-populations of grains. The most abundant fraction is least mobile, and moves with the slowest velocity against gravity. Fractions representative of

Xe-HL peaks, observed in the latest experiment have been studied using aberration-corrected STEM analysis. The results, reported at this meeting [8], provided important feedback.

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