



بِسْمِ

کُوَابِ ارَاذَه مَعَالَه

جناب آقای اسرار خانم: محمد حسن عوض کننده قراول

این لوح به رسم یادبود جهت تقدیر و تشکر از ارائه مقاله تحت عنوان:

Surface Modification of Detonation Nanodiamond

در چهاردهمین کنفرانس شیمی فیزیک ایران که در تاریخ ۹-۱۶ اسفند ۱۳۸۹ در پردیس بین المللی کیش دانشگاه تهران برگزار گردید
تقدیم می گردد. توفیق روز افزون شما در راستای رشد و پایداری علمی کشور عزیزمان ایران از خداوند متعال آرزو مندیم.

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Surface Modification of Detonation Nanodiamond

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One of the major members of nanocarbon family is detonation nanodiamond (DND) that finds more applications in industry. For confirmation we refer to recent reviews [1-3] and a book [4] on nanodiamond materials. One of the primary fields of application is as reinforcement phase in polymer nanocomposites [5]. To insure good dispersion in any media it needs proper surface modification or functionalization [6-10]. The aim of this paper is to study surface modification of DNDs by oxidation in air and concentrated acid treating to generate carboxylic groups.

The DNDs were supplied from NaBond Technologies co. Ltd, China. The as-received (AR) material was studied by TEM, FTIR, and TGA. Two routes were selected for modifying DNDs surface, one way heat treatment (oxidation) in air, and the other way oxidation in air followed by concentrated acids treating (carboxylation). In the first route, some DNDs were placed in crucible in a furnace with air atmosphere in 450°C for 2 hours. Then the heat treated (HT) DNDs were studied by FTIR and TGA. In the second route, 1g HT-DNDs were sonicated in 50 mL, 3:1 mixture of concentrated sulfuric (98%) and nitric (70%) acids in a Branson 3510 sonication bath for 3 hours. Then the mixture was poured in 800 mL, 85°C deionized water and stirred for 10h. Washing of the acid treated (AT) DNDs was done by repeatedly centrifugation and sonication. The resultant slurry was dried in 80°C for 4h in a vacuum oven. The resultant powder was then studied by FTIR. To examine the effects of each modification treatment on dispersion capability of nanoparticles, the AR, HT, and AT powders were dispersed in Isopropanol by 30min sonication. The particle size distribution was determined by a Malvern-MAL1015189 instrument. To investigate the colloidal stability of nanoparticles, they were dispersed in DI water by 30min sonication and then colloidal stability after 2 weeks, 1 month, and 2 months were examined.

The TEM analysis showed that the DNDs are spherical in shape with the average size less than 10nm. The TGA curve showed only one peak around 560°C that corresponds to oxidation of DND itself and also reveals the high purity of the AR material. The FTIR results showed surface functional groups of AR-DNDs are OH, CN, C=O (from CO₂), and COOH. But after oxidation in air the C=O peak was appeared in FTIR spectrum around 1750 cm⁻¹. The other major effect is the oxidation of non-diamond carbon from the surface shell of particles. It is believed that both C=O bonds and non-diamond carbon encourage the agglomeration of particles [6]. The TGA curves before and after heat treatment are both the same. After carboxylation, FTIR spectrum shows only peaks for OH, C-O, and C=O. Such a spectrum corresponds to carboxylic group [11]. Results of particle size analysis are shown in figure 1. It is apparent that the surface modifications strongly influence the dispersion capability of nanoparticles. Among them the AT-DND shows the finest distribution that implies more effectiveness of carboxylation process.

The stability of the nanoparticles in DI water is also investigated. The AR-DNDs are precipitated after 2 weeks that reveals low stability of the sample. The HT and AT-DNDs are almost identical.

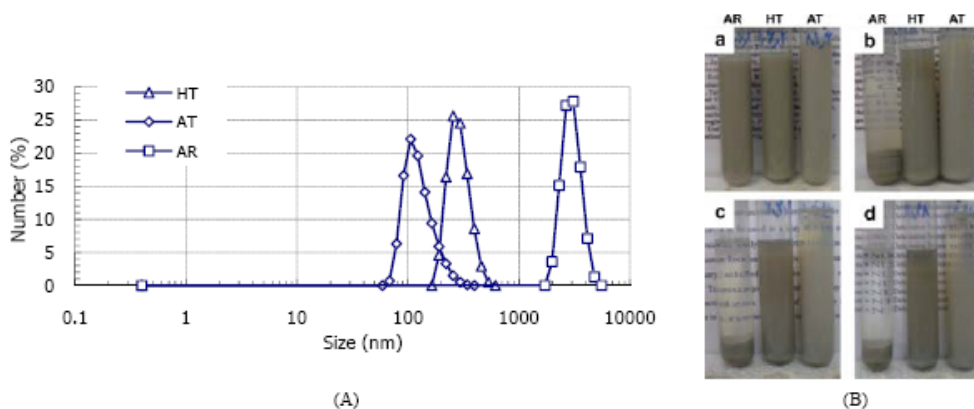


Figure 1 (A) Particle size distribution of AR, HT, and AT-DNDs after 30min sonication in isopropanol and (B) stability of AR-, HT-, and AT-DNDs in DI water after (a) sonication, (b) 2 weeks, (c) 1 month, and (d) 2 months.

Keywords: Detonation nanodiamond, Functionalization, Air oxidation, Carboxylation.



References

- [1] A. M. Schrand, S. A. Ciftan Hens, O. A. Shenderova, *Critical Reviews in Solid State and Materials Sciences* **34** (2009) 18.
- [2] O. A. Shenderova, V. V. Zhirmov, D. W. Brenner, *Critical Reviews in Solid State and Materials Sciences* **27** (2002) 227.
- [3] Y. Hu, O. Shenderova, Z. Hu, C. W. Padgett, D.W. Brenner, *Reports on Progress in Physics* **69** (2006) 1847.
- [4] O. A. Shenderova, D. M. Gruen, Ultrananocrystalline Diamond, William Andrew Publishing, NW, 2006.
- [5] V. Yu. Dolmatov, *Journal of Superhard Materials* **29** (1) (2007) 1.
- [6] O. Shenderova, I. Petrov, J. Walsh *et al.*, *Diamond & Related Materials* **15** (2006) 1799.
- [7] B. V. Spitsyn, J. L. Davidson, M. N. Gradoboev *et al.*, *Diamond & Related Materials* **15** (2006) 296.
- [8] K. D. Behler, A. Stravato, V. Mochalin, G. Korneva, G. Yushin, Y. Gogotsi, *acsnano* **3** (2009) 363.
- [9] S. Ida, T. Tsubota, S. Tanii, M. Nagata, Y. Matsumoto, *Langmuir* **19** (2003) 9693.
- [10] A. Y. Jee, M. Lee, *Current Applied Physics* **9** (2009) e144.
- [11] D. L. Pavia, G. M. Lampman, G. S. Kriz, J. R. Vyvyan, Introduction to Spectroscopy, Brooks/Cole, Cengage Learning, CA, 2009.