Carbon nano-onions – An overview.

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Editorial

Since the discovery of the fullerene C60 in 1985 by Curl, Kroto and Smalley [1] Carbon based nanomaterials were discovered, i.e., carbon nanotubes (CNTs) carbon nano-horns, nano-diamonds and graphene. More than ten years later the initial isolation of gram-quantities of fullerene compounds in 1990 [2]. A multi-layer fullerene is also known as carbon nano-onions (CNOs). The first discovery of the CNOs, Daniel Ugarte [3] is credited with developing a formation mechanism for the creation of spherical graphitic structures by focusing an electron beam on a sample of amorphous carbon. In the last two decade, CNOs has great attention towards due to unique chemical and physical properties. These properties are different from those of other nano-sized carbon materials. Carbon nano-onions consist of spherical closed carbon shells, multi-layered quasi-spherical and polyhedral shaped shells and structure resembling that of an onion. Sometime carbon nano-onion called as carbon onion. In pharmacological applications, CNOs have primarily been explored as potential drug carriers and delivery vehicles. CNOs display poor solubility in both aqueous and organic solvents [4]. This is due to aggregation, promoted by strong intermolecular interactions such as van-der-Waals forces. To overcome the above problem CNO's required attachment of functional group at the surface of CNO's which will improve the solubility.

Chemical functionalization of pristine fullerenes has produced a great library of materials with carefully designed physicochemical properties such as solubility, electron transport ability, thermal stability and photo stability, redox chemistry, and electronic configuration. Basically CNO's can functionalize by the following well known methods namely covalent functionalization, non-covalent functionalization, etc. In particular, covalent modification schemes allow persistent alteration of the electronic properties of the onion, as well as to chemically tailor their surface properties, whereby new functions can be implemented that cannot otherwise be acquired by pristine nano-onions.

The first study was reported by Prato et al. in 2003, which described an azomethine ylide addition reaction on CNOs [5]. Then lot of method have been developed and presented by different author for CNO's functionalization. Covalent functionalization pathways for CNOs are carried out by using reaction mechanism namely alkylation, sulfonation, reduction, oxidation, amidation, radical addition etc. [4]. 1,3-dipolar cycloaddition of CNO's have reported by Georgakilas et al. Rettenbacher et al. and Cioffi et al. [6,7]. Further functionalization strategies for CNOs were reported by Echegoyen et al. [6], who described two novel methods for the functionalization of CNOs and, in addition, a variation of the mentioned 1,3-dipolar cycloaddition of an azomethine ylide. Echegoyen et al. studied the reactivity of CNO's were prepared by different synthesis method with materials of different sizes. [8]. CNO's was oxidized under reflux condition with 3N HNO_3 by Rettenbacher et al. [6]. CNO's was directly fluorinated under a stream of F2 and H2 in a highly reactive environment. The functionalization method was published by Khabashesku et al. [9] and was reported on water-soluble sucrose-functionalized CNOs. [10]. Also Smith et al. reported the first radical addition of a polymer to CNOs in 2007 [11]. Then the further functionalized with bis-o-diynyl arene (BODA), which is known to thermally form reactive bis-radicals [12]. Echegoyen et al. has been reported a first supramolecular CNO/Zn-porphyrin complex [13]. In 2010, novel strategy for addition of a ZnTPP-derivative the surface functionalization of CNOs was published by Flavin et al. [14] Functionalization of CNO nanomaterial by esterification reaction was reported by Bartelmess et al. in 2014 [15]. Also Echegoyen et al. reported for the first time the alkylation of CNOs in 2013 [16].

The recently chemical methods for chemical functionalization of carbon nano-onions have opened up a broad range of novel application. In biomedical application especially in targeted drug delivery system for different cancer therapy, etc. the CNO's are used with significant results. CNO's with different drugs could enhance the pace of drug discovery which would offer savings in money and time. It improves the traditional virtual screening methodologies and also enhances site specific action which will cure the serious diseases like cancer etc. Thus, CNO's could play an important role in designing and development of novel pharmacological therapeutics.

References

1. Kroto HW, Heath JR, O'Brien SC, et al. C60-The third man. Nature 1985;318:162–3.
2. Hebard AF, Rosseinsky MJ, Haddon RC, et al. Superconductivity at 18 K in potassium-doped C60. Nature 1990;350:600–601.
3. Ugarte D. Curling and closure of graphitic networks under electron-beam irradiation. Nature 1992;359:707–9.
4. Bartelmess J, Giordani S. Carbon nano-onions (multi-layer fullerenes): Chemistry and applications. Beilstein J Nanotechnol. 2014;5:1980–8.
5. Georgakilas N, Guldi DM, Signorini R, et al. Organic functionalization and optical properties of carbon onions. J Am Chem Soc. 2003;125:14268–9.
6. Rettenbacher AS, Elliott B, Hudson JS, et al. Preparation and functionalization of multilayer fullerenes (Carbon nano-onions). Chem Eur J. 2006;12:376–387.

7. Cioffi CT, Palkar A, Melin F, et al. A carbon nano-onion-ferrocene donor-acceptor system: Synthesis, characterization and properties. Chem Eur J. 2009;15:4419–7.

8. Palkar A, Melin F, Cardona CM, et al. Reactivity differences between carbon nano onions (CNOs) prepared by different methods. Chem Asian J. 2007;2:625–633.

9. Liu Y, Vander-Waal RL, Khabashesku VN. Functionalization of carbon nano-onions by direct fluorination. Chem Mater. 2007;19:778–6.

10. Kuznetsov OV, Pulikkathara MX, Lobo RFM, et al. Solubilization of carbon nanoparticles, nanotubes, nano-onions, and nanodiamonds through covalent functionalization with sucrose. Russ Chem Bull. 2010;59:1495–5.

11. Rettenbacher AS, Perpall MW, Echegoyen L, et al. Radical addition of a conjugated polymer to multilayer fullerenes (Carbon nano-onions). Chem Mater. 2007;19:1411–7.

12. Bergman RG. Reactive 1,4-dehydroaromatics. Chem Res. 1973;6:25–31.

13. Palkar A, Kumbhar A, Athans AJ, et al. Pyridyl-functionalized and water-soluble carbon nano onions: First supramolecular complexes of carbon nano onions. Chem Mater. 2008;20:1685–7.

14. Flavin K, Chaur MN, Echegoyen L, et al. Functionalization of multilayer fullerenes (carbon nano-onions) using diazonium compounds and “clicks" chemistry. Org Lett. 2010;12:840–3.

15. Bartelmess J, De Luca E, Signorelli A, et al. Boron dipyrromethene (BODIPY) functionalized carbon nano-onions for high resolution cellular imaging. Nanoscale 2014;6:13761–9.

16. Molina-Ontaria A, Chaur MN, Plonska-Brzezinska ME, et al. Preparation and characterization of soluble carbon nano-onions by covalent functionalization, employing a Na-K alloy. Chem Commun. 2013;49:2406–8.

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