Jae Hyun Kim
Mohammed Nazim
DGIST,, 333 Techno Jungang-Daero, Hyeonpung-Myeon, Dalseong-Gun, Daegu 42988, Republic of Korea

jaehyun@dgist.ac.kr

The New Approach of N-Doped Graphene Quantum Dot and its Dispersion in PDMS As a Downconverter

Abstract (Arial Narrow 12)

Crystalline Si solar cell absorbs the light from 400 nm to 1200 nm wavelength range. CIGS solar cell can absorb wide range of solar spectrum in wavelength of 300~1300 nm. This is a theoretical spectrum response. In practical case, there is a great loss in short wavelength below 500 nm. This is due to light absorption by ZnO and CdS layer, which is not contributed to charge carrier generation. When the spectrum range below 500 nm is converted the wavelength above 500 nm using down-conversion nanoparticles, there will be a good improvement of efficiency in CIGS solar cell [1]. There are several reports about graphene quantum dots for spectrum modification [2, 3, 4, 5]. We fabricated an excellent N-doped graphene quantum dot which satisfy the above condition using a simple method. We just used N-containing polymer and graphene oxide and did not use the hydrothermal method which needs high pressure. We could synthesize N-doped graphene quantum dots of high quality by simple heat treatment in a short time (Fig. 1). The absorption range of our graphene quantum dot was 200 ~ 450 nm. When the PL excitation wavelength is 405 nm, the emission wavelength peak was 503 nm. The PL(Photoluminescence) quantum yield was 99 %. These characteristics are excellent for CIGS solar cell application as a down-converter.

For practical application of graphene quantum dot down-converter, it is necessary to make graphene quantum dot dispersed polymer film. We used PDMS (Polydimethyl siloxane) as a polymer. There have been no reports about the graphene quantum dot dispersion in PDMS as far as we know. We observed agglomeration of graphene quantum dots when commercialized PDMS initiator was used. To solve this problem, we synthesized a new initiator to solidify PDMS. We also found the best solvent to dissolve PDMS as shown in table. 1. We tried an additional heat treatment with various temperature (100 ~ 150 ^{o}C) and time (1~ 6 hr). Figure 2 shows that the luminescence of N-doped graphene quantum dots and PDMS composites at the incident UV light of 375 nm. The solvent of PDMS was chloroform.

References

[1] Firoz Khan and Jae Hyun Kim*, ACS Photonics, 5, 11 (2018) 4637.
[2] Dengyu Pan, Jingchun Zhang, Zhen Li and Minghong Wu, Advanced Materials, 22, 6 (2010) 734.
[3] Shujuan Zhuo, Mingwang Shao and Shuit-Tong Lee, ACS Nano, 6, 2 (2012) 1059
[4] P. Tian, L. Tang, K.S. Teng and S. P. Lau, materialstoday CHEMISTRY, 10(2018) 221.
[5] Mitchell Bacon, Siobhan J. Bradley,Thomas, Particle 31(4) (2014) 415

Figures

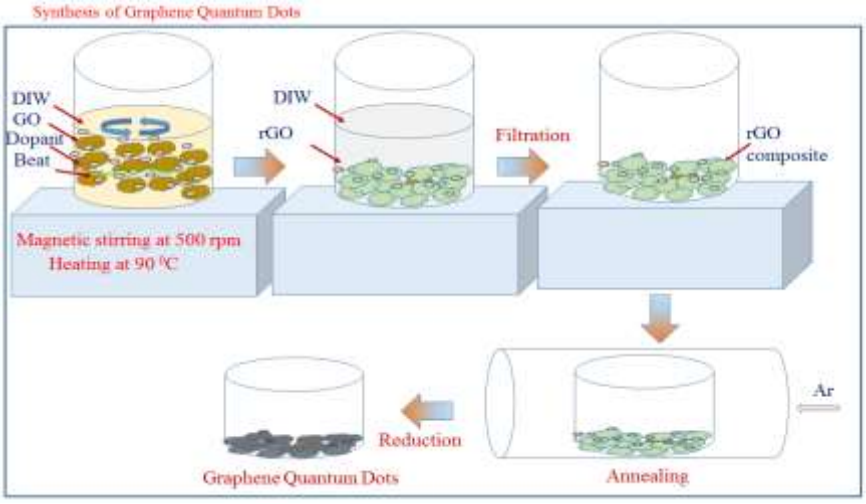

Figure 1: Synthesis process of N-doped graphene quantum dots.

Solvents	Solubility status	After 30 min sonication	Stay after 24h
Chloroform (CF)	Good	Good	Good
Dichloromethane (DCM)	Good	Good	Good
Chlorobenzene (CB)	Good	Good	Good
Dimethylsulfoxide (DMSO)	Not good	Not good	Not good
Dimethylformammide (DMF)	Not good	Not good	Not good
Methanol	Slightly	Partially	Partially
Ethanol	Slightly	Partially	Partially
Isopropanol	Soluble	Soluble	Soluble
1-Butanol	Soluble	Soluble	Soluble
Toluene	Good	Good	Good
Xylene	Good	Good	Good

Table. 1: Solubility of PDMS in organic solvents.

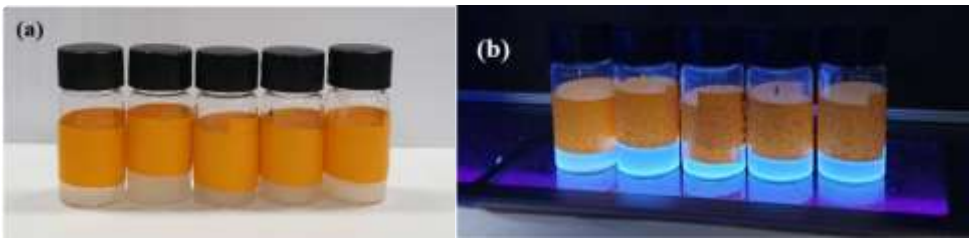

Figure2: PDMS/N-doped graphene quantum dots composite in chloroform with different Initiator concentrations (a) without UV light (b) with UV light.