Optical conductance of Polyaniline composites: A brief review

Shivani Kataria, Sanchit Mondal and Harish Mudila

Department of Chemistry, Lovely Professional University, Punjab, India

Abstract: Polyaniline is one of the most studied and used conducting polymer, polyaniline had a conjugated structure and hence is responsible for various properties such as electrical, electrochemical, optical etc. These properties of polyaniline is augmented by adding certain dopants or by adding specific fillers which also imparts few specific properties to the pristine material along with suppressing the limitation such as poor cyclability and rate capability.

Keywords: Conducting polymers, polyaniline, composites, optical conductivity, bad gap

Introduction: Conducting polymers (CPs) also known as synthetic metals have gathered a substantial consideration in recent times owing to their specific characteristics such as, cost effectiveness, excellent environmental stability, thermal stability, mechanical stability, and electrical and optical conductivity. These characteristics of these CPs had made them to be used for wide applications in the field of conducting adhesives, artificial nerves electromagnetic shielding electrostatic materials, aircraft structures, supercapacitors, pseudocapacitors, batteries, fuel cells, solar cells, diodes, and transistors [1-4]. Variety of CPs are generally used for the above mentioned application which includes, polypyrrole (PPY), polyaniline (PANI), polyacetylene (PACE), polythiophene (PTH), Polyindole (PIN) etc. as majorly studied species. These conducting polymers are blessed with alternate single-double bond structure (conjugation) in them which provide them various conductive properties viz. thermal, electrical and optical [5, 6, 7]. Between the different CPs PANI finds it explicit position for diverse application and had been studied a lot, the electrical conductivity and optical conductivity of PANI is highest between its peers which provides it upper hand in its application. However certain properties of PANI are there which limits its use such as, poor cycling stability and inferior rate capability, these specific limitations can be overcome by certain way viz. doping with acid, p-type or n-type dopants or by adding specific fillers which augment the properties of PANI [8].

Optical conductivity of PANI composites

Nanocomposite of PANI–Ag was synthesized by chemical oxidative polymerization in resence of ammonium peroxydisulphate (APS) A surface plasmon absorption band at 380 nm confirms the presence of Ag nanoparticles in the PANI. It was observed that the optical band gap of PANI–Ag nanocomposite shrinks (2.07 eV) with rising content of Ag nanoparticles while the conductivity increases, also an improvement in photoluminescence was observed for nanocomposite than PANI [9]. Transition metal oxide (TMO)/conducting polymer (CP) (TiO_2 and Co_3O_4 with PANI) heterostructured nanoarrays of high-quality were fabricated by controllable electrochemical polymerization for energy storage applications. A rapid optical intonation and excellent cycalability was studied for TiO_2/PANI nanoarrays while the Co_3O_4/PANI nanoarrays dispalys an improved electrochemical behavior along with a stable capacity [2]. A simple method for fabrication of iodine free dye-sensitized solar cells of PEDOT with TiO_2 with excellent optical performance was developed. The monomer effectively penetrate into the nanopores of the TMO, thus refining the property of the material and thus helping in enhanced dye adsorption and subsequent high performance of the material was acghieved. An outstanding energy conversion competence (5.4%) was obtained thus suggesting iodine-free dye-sensitized solar cells can obliges as an important material for harnessing optical energy [7].

Nanocomposite of PANI- nickel ferrtite ($NiFe_2O_4$, 2.5, 5 and 50 wt%) were fabricated by insitu chemical oxidation polymerization, for studying electrical and optical properties. It was studied that with the % increment of $NiFe_2O_4$ nanoparticles the electrical conductivity of PANI-$NiFe_2O_4$ nanocomposite gets augmented owing to polaron/bipolaron development. While on performing optical absorption experiments an energy band gap 1 eV was obtained for the PANI-$NiFe_2O_4$ nanocomposite [10]. PANi doped with BF_4^- was studied for. Dc electrical conductivity an optical conductivity, the electrical conductivity of PANI was ranged from 0.1 to 10 $(\Omega.cm)^{-1}$, while the optical studies PANI these thin films displayed an absorption peak corresponding to $\pi \rightarrow \pi^*$ electronic transition while a very low band gap (1.6 eV) is observed for the doped polymer [11]. Ternary nanocomposites composed of Multi-walled carbon nanotubes/PANI/magnetite (MWCNTs/PANI/Fe3O4) were fabricated by *Ibrahim et al 2018*, and studied for optical studies In the range of 300–850 nm the transmittance and reflectance (optical properties) of the composite thin films were studied, it was designated through optical absorption data that the composite thin films consist of both direct and indirect band gaps in the range of 2.90–3.41 eV [12]. PANI doped with emeraldine base (PANI-EB), benzene sulphonic acid (PANI-BSA) HCl (PANI-HCl), and BSA and HCl (PANI-HCl-BSA) was synthesied by chemical oxidative polymerization at room temperature (20 °C), so as to study effect of doping on electrical conductivity and band gap values. Electrical conductivity for PANI-EB, PANI-BSA, PANI-HCl-BSA and PANI-HCl doped polymers were found to be decreased respectively with value of 2.9×10^{-4}, 1.39, 0.77 and 0.54 S/cm, while the band gap were found as 3.06, 2.35, 2.38, 2.40 eV for PANI-BSA, PANI-HCl-BSA and PANI-HCl doped polymer respectively [13]. In presence of APS via in situ polymerization of aniline, PANI/ZnO nanocomposite was prepared which was confirmed by spectroscopic techniques. The strong chemical interactions present between CP and ZnO nanoparticle an quantum effect of ZnO and energy band gap difference was responsible for the red shift. The electrical conductivity of nanocomposite was found to be 3×10^{-2} S/cm [14]. Composites of PANI/CNT/CdS quantum dot (2.7–4.8 nm) with 1, 1.5 and 2 wt% of CdS were developed via in-situ polymerization to study enhanced optical and electrical properties. The electrical conductivity for all the composites was much higher as compared to pristine polymer (PANI/CNT/2% CdS was increased with a magnitude of 7), while the band gap values of 3.01 eV, 2.75 eV and 2.63 eV for PANI/CNT/ 1% CdS, PANI/CNT/ 1.5 % CdS and PANI/CNT/ 2% CdS were resulted respectively [15].

Conclusion: Polyaniline is one of the most studied and used conducting polymer, polyaniline had a conjugated structure and hence is responsible for various properties such as electrical, electrochemical, optical etc. These properties of polyaniline is augmented by adding certain dopants or by adding specific fillers which also imparts few specific properties to the pristine material along with suppressing the limitation such as poor cyclability and rate capability.

Reference:

[1] Das, T. K., and Prusty, S. (2012). Review on Conducting Polymers and Their Applications. Polymer-Plastics Technology and Engineering, 51(14), 1487–1500. doi:10.1080/03602559.2012.710697

[2] Xia, X., Chao, D., Qi, X., Xiong, Q., Zhang, Y., Tu, J., Zhang, H. and Fan, H. J. (2013). Controllable Growth of Conducting Polymers Shell for Constructing High-Quality Organic/Inorganic Core/Shell Nanostructures and Their Optical-Electrochemical Properties. Nano Letters, 13(9), 4562–4568. doi:10.1021/nl402741j

[3] Mudila, H., Rana, S., Zaidi, M. G. H., and Alam, S. (2014). Polyindole/Graphene Oxide Nanocomposites: The Novel Material for Electrochemical Energy Storage. Fullerenes, Nanotubes and Carbon Nanostructures, 23(1), 20–26. doi:10.1080/1536383x.2013.787604

[4] Mudila, H., Joshi, V., Rana, S., Zaidi, M. G. H., and Alam, S. (2014). Enhanced electrocapacitive performance and high power density of polypyrrole/graphene oxide nanocomposites prepared at reduced temperature. Carbon Letters, 15(3), 171–179. https://doi.org/10.5714/CL.2014.15.3.171

[5] Kumar, A., Kumar, V., and Awasthi, K. (2017). Polyaniline–Carbon Nanotube Composites: Preparation Methods, Properties, and Applications. Polymer-Plastics Technology and Engineering, 57(2), 70–97. doi:10.1080/03602559.2017.1300817

[6] Kumar, A., Jangir, L. K., Kumari, Y., Kumar, M., Kumar, V., and Awasthi, K. (2015). Optical and Structural Study of Polyaniline/Polystyrene Composite Films. Macromolecular Symposia, 357(1), 229–234. doi:10.1002/masy.201500039

[7] Koh, J. K., Kim, J., Kim, B., Kim, J. H., and Kim, E. (2011). Highly Efficient, Iodine-Free Dye-Sensitized Solar Cells with Solid-State Synthesis of Conducting Polymers. Advanced Materials, 23(14), 1641–1646. doi:10.1002/adma.201004715

[8] Wang, H., Lin, J., & Shen, Z. X. (2016). Polyaniline (PANi) based electrode materials for energy storage and conversion. Journal of Science: Advanced Materials and Devices, 1(3), 225–255. doi:10.1016/j.jsamd.2016.08.001

[9] Gupta, K., Jana, P. C., and Meikap, A. K. (2010). Optical and electrical transport properties of polyaniline–silver nanocomposite. Synthetic Metals, 160(13-14), 1566–1573. doi:10.1016/j.synthmet.2010.05.026

[10] Khairy, M., and Gouda, M. E. (2015). Electrical and optical properties of nickel ferrite/polyaniline nanocomposite. Journal of Advanced Research, 6(4), 555–562. doi:10.1016/j.jare.2014.01.009

[11] Abdulla H. S. and Abbo A. I. (2012). Optical and Electrical Properties of Thin Films of Polyaniline and Polypyrrole. Int. J. Electrochem. Sci., 7, 10666 – 10678.

[12] Ibrahim, A., Abdel-Aziz, M. H., Zoromba, M. S., and Al-Hossainy, A. F. (2018). Structural, optical, and electrical properties of multi-walled carbon nanotubes/polyaniline/Fe 3 O 4 ternary nanocomposites thin film. Synthetic Metals, 238, 1–13. doi:10.1016/j.synthmet.2018.02.006

[13] Manishaben Jaiswal "Big Data concept and imposts in business" International Journal of Advanced and Innovative Research (IJAIR) ISSN: 2278-7844, volume-7, Issue- 4, April 2018 available at: http://ijairjournal.in/Ijair_T18.pdf

[14] Manishaben Jaiswal " SOFTWARE QUALITY TESTING " International Journal of Informative & Futuristic Research (IJIFR) , ISSN: 2347-1697 , Volume 6, issue -2 , pp. 114-119 ,October-2018 Available at: http://ijifr.com/pdfsave/23-12-2019214IJIFR-V6-E2-23%20%20OCTOBER%202018%20a2%20files%20mergeda.pdf

[13] Karaoğlan, N., and Bindal, C. (2018). Synthesis and optical characterization of benzene sulfonic acid doped polyaniline. Engineering Science and Technology, an International Journal. doi:10.1016/j.jestch.2018.09.010

[14] Alam, M., Alandis, N. M., Ansari, A. A., and Shaik, M. R. (2013). Optical and Electrical Studies of Polyaniline/ZnO Nanocomposite. Journal of Nanomaterials, 2013, 1–5. doi:10.1155/2013/157810

[15] Goswami, M., Ghosh, R., Maruyama, T., and Meikap, A. K. (2016). Polyaniline/carbon nanotube/CdS quantum dot composites with enhanced optical and electrical properties. Applied Surface Science, 364, 176–180. doi:10.1016/j.apsusc.2015.12.101