

Influence of graphene concentration in TiO₂-graphene nanocomposites on photocatalytic activity under UV light irradiation

Malgorzata Wojtoniszak, Magdalena Onyszko, Ewa Mijowska

West Pomeranian University of Technology in Szczecin, Institute of Chemical and Environment Engineering, Pulaskeigo 10, 70-322 Szczecin, Poland
mwojtoniszak@zut.edu.pl

Abstract

Graphene has attracted much attention since its discovery in 2004. Because of its exceptional mechanical, electrical, thermal and optical properties, high surface area-to-volume ratio and unique atomic structure, graphene is expected to be applicable in many fields, including electronic devices (sensors, batteries), composites and nanomedicine among others [1-8]. Recently, graphene has been found as an amazing nanocarrier of other particles, for instance titanium dioxide. Hybridization of TiO₂ with graphene affects on improvement of its photocatalytic activity. Electronic interaction between these two nanomaterials influences on transferring of excited electrons from the conduction band of TiO₂ to the surface of graphene, thus improving the separation of the electron-hole pairs and preventing their recombination [9-11]. Furthermore, conjugation graphene with TiO₂ influences on its band gap energy decrease, thus shifting the absorption threshold to the visible light region and allowing utilization of solar energy [11].

In this study, preparation, characterization and photocatalytic activity of TiO₂-graphene nanocomposites will be presented. Nanocomposites were prepared using sol-gel method, followed by calcination at 400 °C, under vacuum or in air atmosphere, to create anatase phase of titanium dioxide adsorbed on graphene surface. In a typical procedure, 5%,7%,10% or 15% of titanium butoxide ethanol solution was mixed with graphene oxide ethanol dispersion in the volume ratio of 1:4, followed by sonication and magnetic stirring for 24 h. Next, the materials were centrifuged for 60 min., washed with ethanol in order to remove excess of titanium dioxide and finally calcinated for 2 h at 400 °C, under vacuum or in air atmosphere. The obtained nanocomposites were denoted as: T-G-5-V, T-G-5-A, T-G-7-V, T-G-7-A, T-G-10-V, T-G-10-A, T-G-15-V and T-G-15-A. Additionally, for comparison purpose, TiO₂ photocatalysts without graphene were prepared under the same conditions. The materials were characterized with transmission electron microscopy, Fourier transform infrared spectroscopy, Raman spectroscopy and diffuse reflectance UV-vis spectroscopy. Photocatalytic activity of the prepared nanomaterials dependent on graphene concentration and calcination conditions was investigated. The photocatalytic activity of the materials was studied in model reactions of phenol decomposition under UV light irradiation.

References

- [1] Y.V. Aristov, G. Urbanik, K. Kummer, D.V. Vyalikh, O.V. Molodtsova, A.B. Preobrajenski et al., *Nano Lett.* 10 (2010) 992.
- [2] H. Zhao, K. Min, N.R. Aluru, *Nano let.* 9 (2009) 3012.
- [3] Y. Zhang, T.T. Tang, C. Girit, Z. Hao, M.C. Martin, A. Zettl et al., *Nature* 459 (2009) 820.
- [4] N.V. Medhekar, A. Ramasubramaniam, R.S. Ruoff, V.B. Shenoy, *Acs nano.* 4 (2010) 2300.
- [5] S. Wang, M. Tambraparni, J. Qiu, J. Tipton, D. Dean, *Macromolecules* 42 (2009) 5251.
- [6] Y. Chang, *Toxicol. Lett.* 200 (2010) 201.
- [7] S. Stankovich, D.A. Dikin, G.H.B. Dommett, K.M. Kohlhaas, E.J. Zimney, E.A. Stach et al., *Nature* 442 (2006) 282.
- [8] J.D. Fowler, M.J. Allen, V.C. Tung, Y. Yang, R.B. Kaner, B.H. Weiller, *ACS Nano* 3 (2009) 301.
- [9] X.Y. Zhang, H.P. Li, X.L. Cui *Chin. J. Inorg. Chem.* 25 (2009) 1903.
- [10] M. Wojtoniszak, B. Zielinska, R.J. Kalenczuk, E. Mijowska *Materials Science-Poland* 30 (2012) 32.
- [11] M. Wojtoniszak, B. Zielinska, X. Chen, R.J. Kalenczuk, E. Mijowska *J Mater Sci* 47 (2012) 3185.

Figures

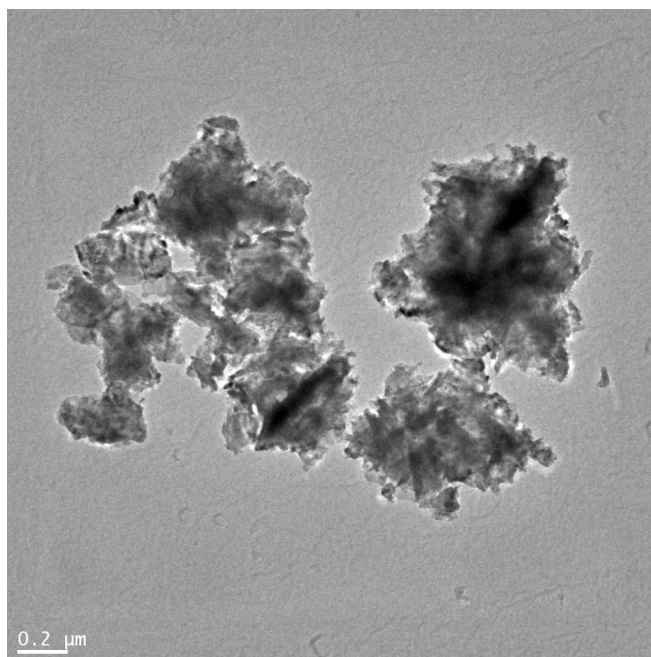


Figure 1. Transmission electron microscopy image of TiO₂-graphene nanocomposite denoted as T-G-10-V.

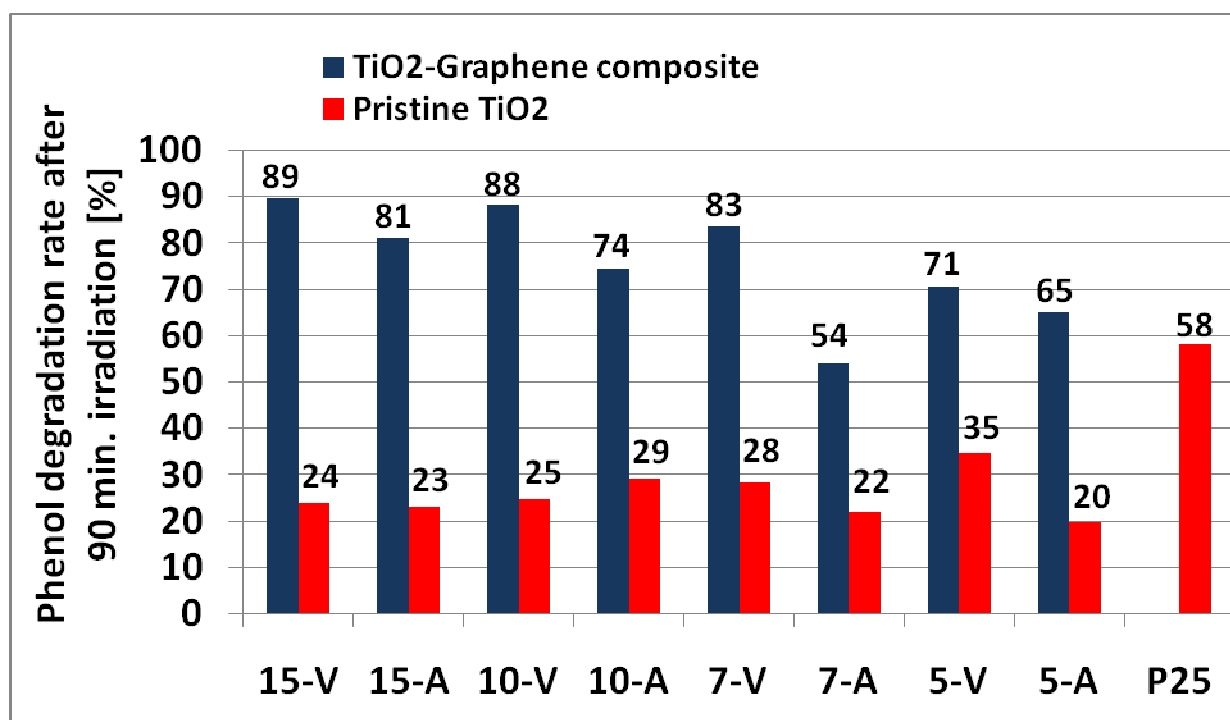


Figure 2. Photocatalytic activity of TiO₂-graphene nanocomposites and pristine TiO₂ photocatalysts measured as phenol degradation rate after 90 minutes irradiation.