www.amlett.com, www.vbripress.com/aml, DOI: 10.5185/amlett.2015.5914

Published online by the VBRI Press in 2015

Preparation of epoxy graphene and its structural and optical properties

Srinivasarao Yaragalla¹, Gopinathan Anilkumar², Vineeshkumar T. V.³, Nandakumar Kalarikkal^{1,3*}, Sabu Thomas^{1,2*}

¹International and Inter University Centre for Nanoscience and Nanotechnology, Mahatma Gandhi University, Kottayam 686560, Kerala, India ²School of Chemical Sciences, Mahatma Gandhi University, Kottayam 686560, Kerala, India ³School of Pure and Applied Physics, Mahatma Gandhi University, Kottayam 686560, Kerala, India

^{*}Corresponding author. Tel: (+91)- 481- 2730003; E-mail: sabupolymer@yahoo.com, sabuchathukulam@yahoo.co.uk (S. Thomas), Tel: (+91)- 481- 2730003; E-mail: nkkalarikkal@mgu.ac.in (N. Kalarikkal)

Received: 23 March 2015, Revised: 22 June 2015 and Accepted: 26 June 2015

ABSTRACT

Epoxy graphene (EG) was synthesized from graphite (GT) powder using meta chloroperbenzoic acid (mCPBA) as an oxidizing agent at room temperature. Structural properties of the prepared EG were investigated by Fourier transform infrared (FT-IR) spectroscopy, Raman spectroscopy and UV-visible spectroscopy. Results of FT-IR and Raman spectroscopy confirmed that the epoxy groups are incorporated into graphene basal planes. The layered structure of EG was determined using transmission electron microscope (TEM). Optical properties of the prepared EG were analyzed using UV-visible spectroscopy and Photo luminescence (PL) spectroscopy. From the UV-visible spectroscopy data, the band gap of EG was found to be 4.1 eV and this energy gap was roughly correlated with the maximum photoemission behavior of EG and the fluorescence energy was found to be dependent on the excited wavelength. These novel functional materials could be used for applications in the field of opto-electronic and light emitting devices. Copyright © 2015 VBRI Press.

Keywords: Epoxy graphene; graphite; spectroscopy; band gap; optical properties.

Introduction

The development of stable and high photo luminescent materials is very important for technological applications such as biological labeling, use in optoelectronic devices and so on [1, 2]. Immense efforts have been made to improve and manufacture new and efficient photo emitters such as silicon nanoparticles [2], semiconductor quantum dots [1] and carbon based materials including nanodiamond and carbon nanotubes [3]. Carbon nanomaterials have received much attention owing to their unprecedented electrical and mechanical properties and also due to diverse applications in various fields [4-8]. Graphene is one of the most famous carbon nanomaterials and is the building unit of graphite, carbon nanotubes and fullerenes. Graphene is more fascinating among all carbon based nanomaterials due to the hexagonal arrangement of carbon atoms, high surface area, Youngs modulus (1TPa) [9] and room temperature electrical conductivity $(15000 \text{ cm}^2 \text{.V}^{-1} \text{.s}^{-1})$ [10] owing to the π electron conjugation. Earlier, single layer graphene was generated from bulk graphite through scotch tape mechanical exfoliation [11] and epitaxial chemical vapor deposition methods [12]. However, these methods were not useful for large scale production. Strong oxidizing agents have been used commonly to exfoliate graphite into graphite oxide, which on further sonication gives graphene

oxide (GO) and it is an insulative hydrophilic carbon material [13, 14]. The determination of the exact structure of GO and the quantity of the functional groups on graphite basal planes are still complicated. However, it is evident from previous studies that the aromatic architecture of graphite is disturbed by epoxy, carboxyl and hydroxyl groups during the oxidation process [15, 16]. GO was first synthesized by Brodie in 1859 through oxidation of graphite with small portions of potassium chlorate and fuming nitric acid [17]. Staudenmaier improvised this method to prepare highly oxidized GO using a mixture of sulfuric acid and nitric acid followed by the addition of chlorate to the reaction mixture [18]. Later on, Hummer proposed an alternative method for the preparation of GO using NaNO₃, KMnO₄ and H₂SO₄ [19]. However, these methods are not eco-friendly because of the generation of toxic gases like N₂O₄ NO₂ and ClO₂ during the course of reaction. More innovative ideas and careful investigations are needed for generating functionalized graphene from the chemist's point of view in order to overcome the toxicity aspects. One of the prerequisites for functionalizing graphene is the enhancement of the compatibility with other components such as solids and liquids which lead to the exploration of the intriguing properties of graphene based composite materials. Moreover, functional groups can be incorporated into graphene basal planes to regulate the band gap and thus help in tuning the optical and electronic properties of graphene materials. These materials can be used for technological and industrial applications. Many research studies have been carried out on the covalent and non-covalent functionalization of graphene [20-24] using different preparation techniques. To the best of our knowledge, no report has so far been published for the preparation of EG from graphite using mCPBA as an oxidizing agent. In this work, a novel method for the preparation of epoxy graphene has been reported and the optical properties of EG are investigated. Graphite was used as the initial precursor with *m*-CPBA as the oxidizing agent. The oxidized product was sonicated to exfoliate epoxy graphite to epoxy graphene using bath sonicator. Structural and optical properties of epoxy graphene were studied in detail. The interesting fact about this method is that less toxic materials are used compared to the Hummer method [19] where high concentration of acid is used. Moreover, in Hummer method, toxic gases are also produced during the reaction process.

Experimental

Materials

Graphite powder, meta-Chloroperbenzoic acid (mCPBA), Dichloromethane (DCM) and N, N-Dimethylformamide (DMF) were procured from Sigma Aldrich and were used without further purification.

Preparation of epoxy graphene

Graphite powder (250 mg) was added to DCM (50 ml) in a round bottom flask (RBF). After dispersing the graphite powder in DCM by stirring mCPBA (1.5 g) was slowly added to the graphite mixture and the stirring was continued up to 24 hrs. The crude solid was filtered, then washed with sodium bicarbonate solution and dried in hot air oven at 40 $^{\circ}$ C. Thereafter, the solid obtained was sonicated using a bath sonicator for 10-15 minutes. Finally the solid was filtered using Whatman filter paper and dried in a hot air oven at 60 $^{\circ}$ C.

Experimental methods

The morphology of functionalized graphene was analyzed by TEM (JEOL). Epoxy graphene powder (1 mg) was sonicated using a bath sonicator for 5 minutes in water as solvent and then drop cast on TEM grid prior to analysis. Fourier transform infrared (FT-IR) spectra of the samples were recorded by Shimadzu IR prestige 21 FT-IR spectrometer with ZnSe attenuated total reflectance (ATR) attachment. Samples were analyzed in the frequency range between 4000-500 cm⁻¹. All the spectra were baseline corrected using IR solution software Shimadzu. Bruker Senterra dispersive Raman microscope spectrometer was used to understand the structural changes of graphite and functionalized graphene materials with a laser excitation wavelength of 532 nm. All peaks were normalized using spectrum software prior to interpret the data. Thermo gravimetric diagram of the samples was measured by a Perkin Elmer, Diamond TG/DTA analyzer with a heating rate of 10 °C min⁻¹. Absorption spectra were carried out using JascoV-650 absorption spectrometer and the samples

(1 mg/3 ml) were dissolved in DMF solvent prior to analysis with the wavelength ranging from 200 nm to 800 nm. Horiba scientific Fluromax-4spectrometer was used to evaluate the emission spectra of functionalized graphene materials. The sample preparation is same as in the case of absorption spectra.

Results and discussion

Transmission electron microscopy (TEM) was used to characterize the morphology and the surface structure of EG. The layered structure of EG is shown in **Fig. 1**. From the figure, it is clear that the graphite layers have been separated nicely and in certain portions folded structures were also observed. Several reports revealed the folded nature of GO [25-27].



Fig. 1. TEM micrographs of epoxy graphene.

Generally, FT-IR is an essential instrument used to identify the structural changes and functional groups present in the organic or inorganic compounds. The structural transformation from graphite to epoxy graphene was recognized through FT-IR and is shown in **Fig. 2**.



Fig. 2. FT-IR spectra of graphite and epoxy graphene.

From the figure it is clear that there is no significant peak for graphite since there is no specific functional group present in the graphite. After oxidation of graphite with m-CPBA, EG showed peaks at 1008 cm⁻¹ and 1217 cm⁻¹ corresponding to terminal (-C-O) and non-terminal (-C-O) oxirane (epoxy) rings [**28**, **29**]. Hummer method [**19**] is the

Yaragalla et al.

most commonly used procedure for oxidizing graphite for graphene based composite materials. This method introduces various kinds of functional groups such as hydroxyl, carboxy, epoxy and ketonic groups on graphitic basal planes during oxidation of graphite. In this study, we selectively decorated only with epoxy groups on the graphite basal planes using m-CPBA as the oxidizing agent. From the FT-IR data, one can conclude that the graphite has been successfully oxidized to graphene oxide, which clearly substantiate that the epoxy groups were successfully decorated on the graphitic basal planes.

Raman spectroscopy is a sensitive and essential tool to characterize the graphite and graphene associated materials **[30]**.



Fig. 3. (a) Raman spectra and (b) TGA plots of graphite and epoxy graphene.

Raman spectra of graphite and EG are shown in **Fig. 3(a)**. Neat graphite shows the deformation D band at 1364 cm⁻¹ and the strong graphitic G band at 1578 cm⁻¹ which correspond to deformations and graphitic structures of carbon atoms. It is also associated with the breathing mode of k-point phonons of A_{1g} symmetry (vibrations of dangling carbon atoms of graphite). In addition, the position of the G band has shifted to higher frequencies in the order of EG > GT, which is mainly ascribed to the decrease in number of graphitic layers in solid state [**31**]. GT shows second harmonic D band that is 2D at 2704 cm⁻¹. Upon oxidation of graphite, the intensity of 2D band got reduced and broadened in the case of EG, which clearly demonstrate that the defects are created by epoxy functional groups on the graphitic planes [32]. Moreover, the I_D/I_G ratio of graphite and EG is 0.86 and 1.13 respectively. The main reason for the increment in the I_D/I_G ratio of EG can be attributed the fact that some of the sp² carbons are converted to sp³ carbons during the oxidation process of graphite. Besides, dramatic improvement in intensity of D band and reduction of G band were observed in the case of EG owing to the incorporation of epoxy groups during functionalization of graphite. The Raman results delineated above agree well with those reported by XU et al [32] and stanchovich et al [33].

The thermal stability of the prepared epoxy graphene and graphite was tested using TGA. **Fig. 3(b)** illustrates the TGA plots of graphite and epoxy graphene. As shown in **Fig. 3(b)**, both graphite and epoxy graphene start to lose mass at100 °C due to adsorbed moisture. The TGA curve of epoxy graphene showed high weight losses around 350 °C and 650 °C as compared to the neat graphite presumably attributed to the pyrolysis of the labile epoxy groups [**34**-**36**]. The extent of degradation in terms of weight loss of epoxy graphene is greater than that of neat graphite. Characterization of EG was also done using absorption spectroscopy and is shown in **Fig. 4(a)**.



Fig. 4. (a) UV-Visible spectra and (b) Tauc plot of epoxy graphene.

Sample was dispersed in dimethylformamide (DMF) prior to analysis. EG shows absorption at 277 nm and it corresponds to $n-\pi^*$ transition which arises owing to the oxygen atoms of epoxy groups and graphite carbon skeleton [37, 38]. Generally, pure single layer graphene is

Research Article

a zero band gap material. However, the band gap of graphene can be tuned by incorporating foreign materials or functional groups. **Fig. 4(b)** illustrates the band gap of EG and was calculated using Tauc plot with linear extrapolation [**39**] (band gap energy (eV) was taken on X axis and product of absorbance (α) and energy (hu) was taken on Y axis). From the Tauc plot, the band gap of EG was found to be 4.1 eV. Hsu *et al.* [**40**] reported the band gap of GO around 3.2 to 3.9; however, they adopted a different preparation method. The whole reaction progress of preparation protocol of EG is shown in **Fig. 5**.



Fig. 5. Reaction progress of epoxy graphene from graphite.

Carbon fluorescent materials have been attracting much attention since they exhibit more stable emission. Photoluminescence of these carbon based materials are associated with poly aromatic structures of carbon atoms and or passivated defects caused by functional groups [41, 42]. Fig. 6(a) describes the fluorescence spectra of EG at various excited wavelength from 300 to 360 nm. Initially, EG shows a broad peak at 390 nm and a small less intensity shoulder at 324 nm when the sample is excited at 280 nm wavelength. These peak intensities were enhanced with the increment of excited wavelength up to 300 nm. Thereafter, further increment in excited wavelength from 300 nm to 360 nm, the photo emission peak at 324 nm gradually shifted to higher wavelengths and the intensity of emission peak at 390 nm decreased gradually. This phenomenon clearly indicates the broad energy density states of EG because the defects are created by epoxy groups. Moreover, the maximum photo emission was observed at 310 nm. It is well known that pure single layer graphene is a zero band gap semiconductor since it cannot show fluorescent emission properties. It is of significant interest to open up the band gap of graphene through functionalization and thus tuning the optoelectronic properties. The functionalization through *m*-CPBA opens up the band gap of graphene and was found to be 4.1 eV calculated using Tauc equation from UV data. This is the reason for the maximum photo emission of EG at 310 nm excited wavelength. The schematic band diagram of EG is shown in **Fig.** 6(b) (G and G¹ are the ground and excited energy levels of EG). These functionalized graphene materials could be used as potential candidates for light emitting and optoelectronic devices. Experiments are ongoing for fabricating these devices using epoxy graphene.



Fig. 6. (a) PL spectra and (b) Schematic energy band diagram of epoxy graphene.

Conclusion

Epoxy graphene has been successfully synthesized from graphite using mCPBA as an oxidizing agent. This method is novel, simple and easy to handle. Structural and morphological properties of epoxy graphene have been confirmed by FT-IR, Raman spectroscopy, UV-Visible spectroscopy and TEM. The band gap of EG was found to be 4.1 eV using UV spectroscopy. Photo emission of EG is dependent on excited wavelength and also the whole range of photo emission values is in the visible region. Undoubtedly, this EG can be exploited in visible light emitting devices. Moreover, this novel path for functionalization of graphene can help to disperse the graphitic material in various polar polymeric components which could be utilized in the area of polymer composites as well as material science.

Acknowledgements

We would like to thank to the University Grants Commission (U.G.C), New Delhi and the DST Nano mission, New Delhi for their financial support. Our special thanks to STIC CUSAT for providing the TGA analysis.

Author contributions

Conceived the plan:Thomas, Kalarikkal, Yaragalla; Performed the expeirments: Yaragalla, Gopinathan; Data analysis: Yaragalla, T.V. Wrote the paper: Yaragalla, Gopinathan. Authors have no competing financial interests.

Reference

- Bruchez, M.; Moronne, M.; Gin, P.; Weiss, S.; Alivisatos, A. P.; Science, 1998, 281, 2013. DOI: <u>10.1126/science.281.5385.2013</u>
- Warner, J. H.; Hoshino, A.; Yamaomto, K.; Tilley, R. D.; Angew. Chem. Int. Ed. 2005, 44, 4550.
- DOI: <u>10.1002/anie.200501256</u>
 Riggs, J. E.; Guo, Z. X.; Carroll D. L.; Sun, Y. P.; *J. Am. Chem. Soc.* 2000, *122*, 5879.

DOI: 10.1021/ja9942282

- Saxena, S.; Tyson, T. A.; ACS Nano, 2010, 4, 3515. DOI: <u>10.1021/nn100626z</u>
- Li, B. Q.; Li, Y.; Zhang, X.; Chikkannanavar, S. B.; Zhao, Y.; Dangelewicz, A. M.; Zheng, L.; Doorn, S. K.; Peterson, Q. J. D. E.; Arendt, P. N.; Zhu, Y.; *Adv. Mater.* **2007**, *19*, 3358.
 DOI: <u>10.1002/adma.200602966</u>
- Herman, I.; Yeo, J.; Hong S.; Lee, D.; Nam, K. H.; Jun-ho, C.; Wonhwa, H.; Lee, D.; Grigoropoulos, C. P.; Ko, S. H.; *Nanotechnol.* 2012, 23, 194005.
 DOI: <u>10.1088/0957-4484/23/19/194005</u>
- Shao, Y.; Wang, J.; Hong, W.; Jun, L.; Aksay, I. A.; Yuehe, L.; *Electroanal*, 2010, 22, 1027. DOI: 10.1002/elan.200900571
- Stakovich, S.; Dikin, D. A.; Piner, R. D.; Kohlhaas, K. A.; Kleinhammes, A.; Jia, Y.; Wu, Y.; Nguyen, S. T.; Ruoff, R. S.; *Carbon*, 2007, 45, 1558.
 DOI: 10.1016/j.carbon.2007.02.034
- Lee, C.; Wei, X.; Kysar, J. W.; Hone, J.; Science, 2008, 321,5887. DOI: 10.1126/science.1157996
- Geim A. K.; Novoselov, K. S.; *Nat. Mater.* 2007, *6*, 183. DOI: <u>10.1038/nmat1849</u>
- Novoselov, K. S.; Geim, A. K.; Morozov, S. V.; Jiang, D.; Zhang, Y.; Dubonos, S. V.; Grigorieva, I. V.; Firsov, A. A.; *Science*, **2004**, *306*, 666.
 - **DOI:** <u>10.1126/science.1102896</u>
- Berger, C.; Song, Z.; Li, X.; Wu, X.; Brown, N.; Naud, C.; Mayou, D.; Li, T.; Hass, J.; Marchenkov, A. N.; Conrad, E. H.; First, P. N.; de Heer, W. A.; *Science*, **2006**, *312*, 1191.
 DOI: <u>10.1126/science.1125925</u>
- Higginbotham, A. L.; Lomeda, J. R.; Morgan, A. B.; Tour, J. M. Appl. Mater. Interfaces. 2009, 1, 2256.
 DOI: <u>10.1021/am900419m</u>
- 14. Ruoff, R.; Nat Nanotechnol. 2008, 3, 10.
- DOI: <u>10.1038/nnano.2008.215</u>
 15. He, H.; Klinowski, J.; Forster, M.; Antone, L.; *Chem. Phys. Lett.* **1998**, 287, 53.
- **DOI:** <u>10.1016/S0009-2614(98)00144-4</u> 16. Lerf, A.; He, H.; Forster, M.; Klinowski, J.; *J. Phys. Chem.* B. **1998**,
- *102*, 4477. **DOI:** <u>10.1021/jp9731821</u>
- Brodie, B. C.; *Philos. Trans. R. Soc. London* 1859, 14, 249.
 DOI: <u>10.1021/ja0764730</u>
- Staudenmaier, L.; Ber. Dtsch. Chem. Ges. 1898, 31, 1481.
 DOI: <u>10.1021/ja0764730</u>
- Hummers, W. S.; Offeman, R. E.; J. Am. Chem. Soc. 1958, 80, 1339. DOI: <u>10.1021/ja01539a017</u>
- Yang, H.; Shan, C.; Li, F.; Han, D.; Zhang Q.; Niu, L.; *Chem. Commun.*, 2009, 3882.
 DOI: 10.1039/b905085j
- Avinash, M. B.; Subrahmanyam, K. S.; Sundarayya, Y.; Govindaraju, T.; *Nanoscale*, **2010**, *2*, 1762.
 DOI: 10.1039/C0NR00024H
- Yang, H.; Li, F.; Shan, C.; Han, D.; Zhang, Q.; Niu L.; Ivaska A.; J. Mater. Chem., 2009, 19, 4632.
 DOI: 10.1039/b901421g
- Choi, E.-Y.; Han, T.H.; Hong, J.; Kim, J.E.; Lee, S.H.; Kim, H.W.; Kim, S.O.; *J. Mater.Chem.* 2010, 20, 1907. DOI: 10.1039/B919074K
- 24. Kuila, T.; Bose, S.; Kumar, A.; Khanra, P.; Kim, N. H.; Lee, J. H.; *Prog. Mater Sci.* **2012**, *57*, 061. **DOI:** <u>10.1016/j.pmatsci.2012.03.002</u>
- Hu, H.; Xin, J. H.; Hu, H.; Wang X.; Lu, X.; Molecules, 2014, 19, 7459.
- DOI: <u>10.3390/molecules19067459</u>
 Lu, G.; Mao, S.; Park, S.; Ruoff, R. S.; Chen, J.; *Nano Res* **2009**, *2*, 192.
- **DOI:** <u>10.1007/s12274-009-9017-8</u>
- Verma, S.; Mungse, H. P.; Kumar, N.; Choudhary, S.; Jain, S. L.; Sain, B.; Khatri, O. P.; *Chem. Commun.*, **2011**, *47*, 12673 . DOI: <u>10.1039/C1CC15230K</u>
- Creegan, K. M.; Robbins, J. L.; Robbins, W. K.; Millar, J.M.; Sherwood, R.D.; Tindall, P. J. D.; Cox, M.; Smith, A. B.; McCauley, J. P.; Jones, D. R.; Gallagher, R. T.; *J. Am. Chem. Soc.* 1992, *114*, 1103.
 DOI: <u>10.1021/ja00029a058</u>

- Tung, V. C.; Allen, M. J.; Yang, Y.; Kaner, R. B.; *Nat. Nanotechnol.* 2009, *4*, 25. DOI: 10.1038/nnano.2008.329
- Rao, C.N.R.; Biswas, Kanishka, Subrahmanyam, K. S.; Govindaraj, A.; J.Mater. Chem. 2009, 19, 2457.
 DOI: <u>10.1039/B815239J</u>
- Chieu, T. C.; Dresselhaus, M. S.; *Phys. Rev. B*, **1982**, *26*, 5867.
 DOI: <u>10.1103/PhysRevB.26.5867</u>
- Xu, Y. X.; Bai, H.; Lu, G. W.; Li, C.; Shi, G. Q.; J. Am. Chem. Soc. 2008, 130, 5856.
 DOI: 10.1021/ja800745y
- 33. Stankovich, S.; Dikin, D. A.; Piner, R. D.; Kohlhaas, K. A.; Kleinhammes, A.; Jia, Y.; Wu, Y.; Nguyen, S.T.; Ruoff, R.S.; *Carbon*, 2007, 45, 1558.
 DOI: 10.1016/j.carbon.2007.02.034
- 34. Fan, Z.; Wang, K.; Wei, T.; Yan, J.; Song, L; Shao, B.; Carbon, 2010, 48, 1686.
- DOI: <u>10.1016/j.carbon.2009.12.063</u>
 35. Fan, Z.; Wang, K.; Wei, T.; Yan, J.; Wei, T.; Zhi, L.; Feng, J.; Ren, Y.; Song, L.; Wei, F.; *ACS Nano*, **2011**, *5*, 191.
- DOI: <u>10.1021/nn102339t</u>
 36. Che, J.; Shen, L.; Xiao, Y.; *J. Mater. Chem.* **2010**, *20*, 1722.
 DOI: <u>10.1039/B922667B</u>
- Luo, Z.; Lu, Y.; Somers L. A.; Johnson, A. T. C.; J. Am. Chem. Soc. 2009, 131, 898.
- DOI: <u>10.1021/ja807934n</u>
 38. Liu, Z-B.; Xu, Y-F.; Zhang, X-Y.; Zhang, X-L.; Chen Y-S.; Tian, J-G.; *J. Phys. Chem.* B, **2009**, *113*, 9681.
 DOI: <u>10.1021/jp9004357</u>
- Tauc, J.; *Mater.Res.Bull*, **1968**, *3*, 37.
 DOI: 10.1016/0025-5408(68)90023-8
- Hsu, H-C.; Indrajit, S.; Wei, H-Y.; Chang, Y-C.; Du, H-Y.; Lin, Y-G.; Tseng, C-A.; Wang, C-H.; Chen, L-C.; Lin, Y-C.; Chen, K-H.; *Nanoscale*, 2013, 5, 262.
 DOI: 10.1039/C2NR31718D
- Lin, Y.; Zhou, B.; Martin, R. B.; Henbest, K. B.; Harruff, B. A.; Riggs, J. E.; Guo, Z. X.; Allard L. F.; Sun, Y. P.; *J. Phys. Chem. B.* 2005, 109, 14779.
 DOI: 10.1021/jp053073j
- Yu, S. J.; Kang, M. W.; Chang, H. C.; Chen K. M.; Yu, Y. C.; J. Am. Chem. Soc. 2005, 127, 17604.
 DOI: <u>10.1021/ja0567081</u>



Publish your article in this journal

Advanced Materials Letters is an official international journal of International Association of Advanced Materials (IAAM, <u>www.iaamonline.org</u>) published by VBRI Press AB, Sweden monthly. The journal is intended to provide topquality peer-review articles in the fascinating field of materials science and technology particularly in the area of structure, sysnthesis and processing, characterisation, advanced-scate properties, and application of materials. All published articles are indexed in various databases and are available download for free. The manuscript management system is completely electronic and has fast and fair peer-review process. The journal includes review article, research article, notes, letter to editor and short communications.

