# Supporting Information

# Aqueous electromigration of single-walled carbon nanotubes and co-electromigration with copper ions

Pavan M. V. Raja,[a] Gibran L. Esquenazi,[a] Kourtney D. Wright,[a] Cathren E. Gowenlock,[b] Bruce E. Brinson,[a,c] Shirin Alexander,[b] Daniel R. Jones,[b] Varun Shenoy Gangoli,[a,c] and Andrew R. Barron*[a,b,d]

---

[a] *Department of Chemistry, Rice University, Houston, TX 77005, USA. E-mail: arb@rice.edu*
[b] *Energy Safety Research Institute, Swansea University Bay Campus, Swansea, SA1 8EN, UK. a.r.barron@swansea.ac.uk*
[c] *Smalley-Curl nanoCarbon Center, Rice University , Houston, Texas 77005, USA.*
[d] *Department of Materials Science and Nanoengineering, Rice University, Houston, Texas 77005, USA*

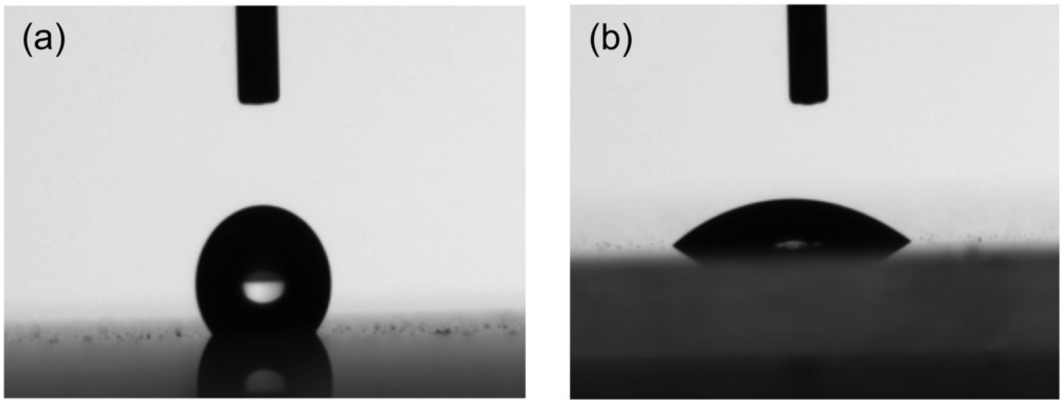

**Fig. S1.** Photographs of water droplets of films of (a) raw SWCNTs and (b) acid treated base neutralized SWCNTs (a-SWCNTs).

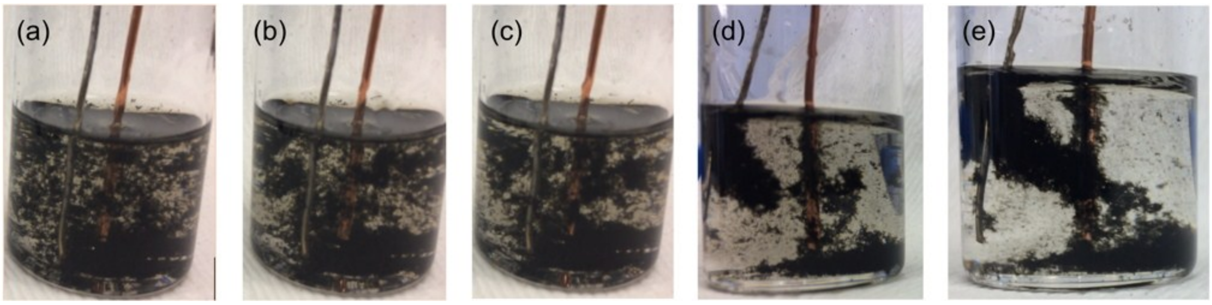

**Fig. S2.** Left electrode: anode (platinum), right electrode: cathode (copper). As-received raw HiPco SWCNTs sonicated in DMF and subjected to 14.4V DC for (0 s, 43 s, 59 s, 5 min, and 15 min).

**Fig. S3.** Photographs of raw SWCNTs before electrolysis in DI water.

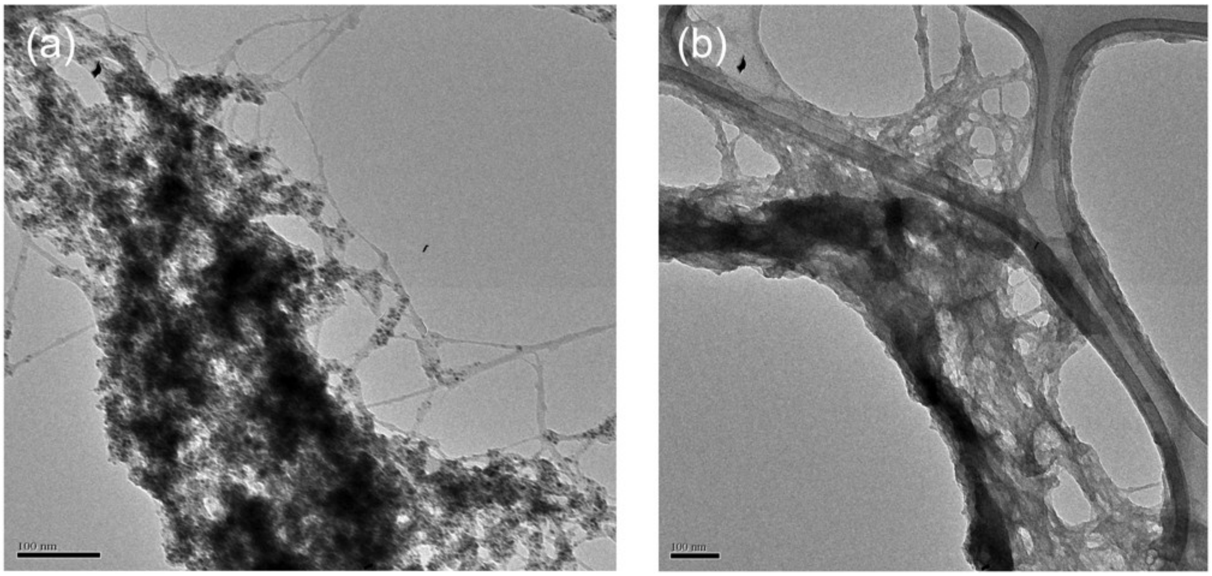

**Fig. S4.** TEM images of raw (a) and purified (b) HiPco SWCNTs. Scale bar = (a) 200 nm and (b) 100 nm.

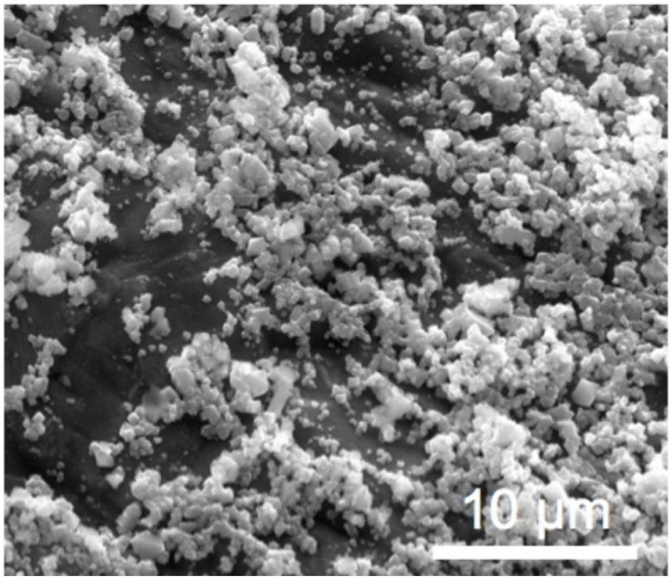

**Fig. S5.** SEM images of the anode after electrolysis of raw SWCNTs in the presence of $Cu^{2+}$ ions. Scale bar = 10 μm.

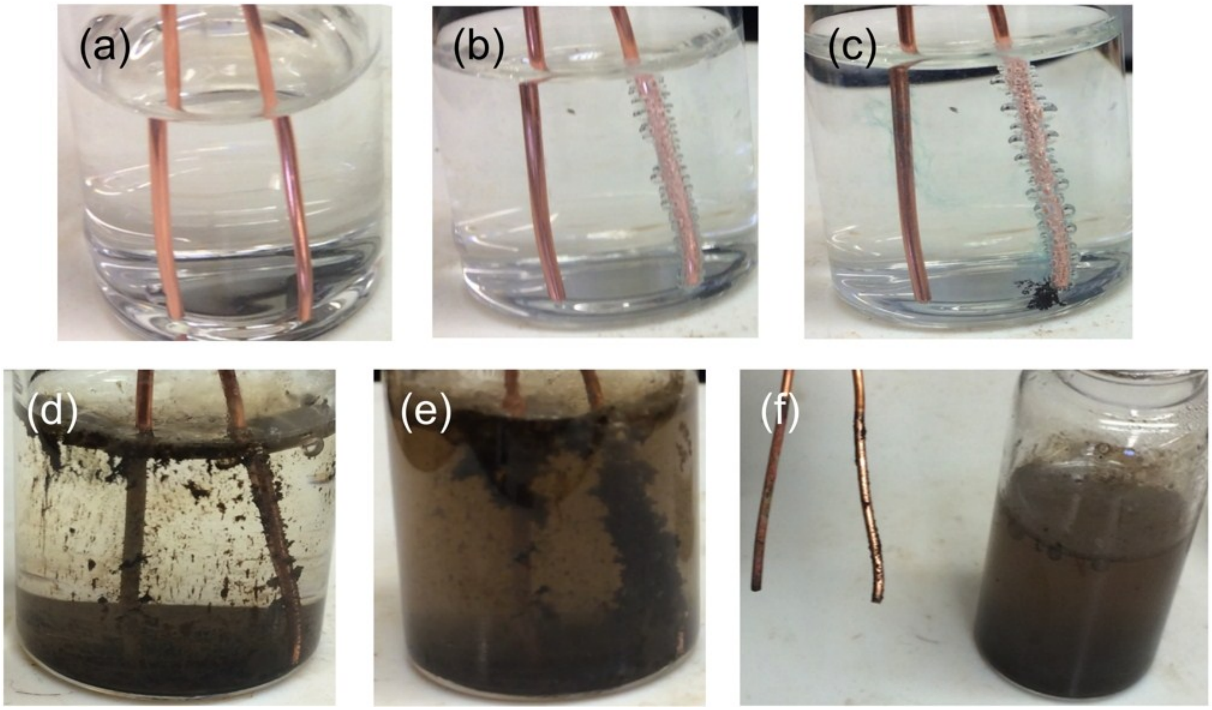

**Fig. S6.** Photographs of a control experiment using copper electrodes in DI water (no additives) before and after various time intervals of electrolysis: (a) 0 s, (b) 218 s, (c) 642 s, (d) 80 min, (e) 287 min, and (f) 288 min. The left electrode is the anode while the right electrode is the cathode. Blue coloration is seen 218 s onwards suggesting electrode exchange of copper ions was slow and was eventually masked by the brownish-black precipitate generated during the electrolytic process.

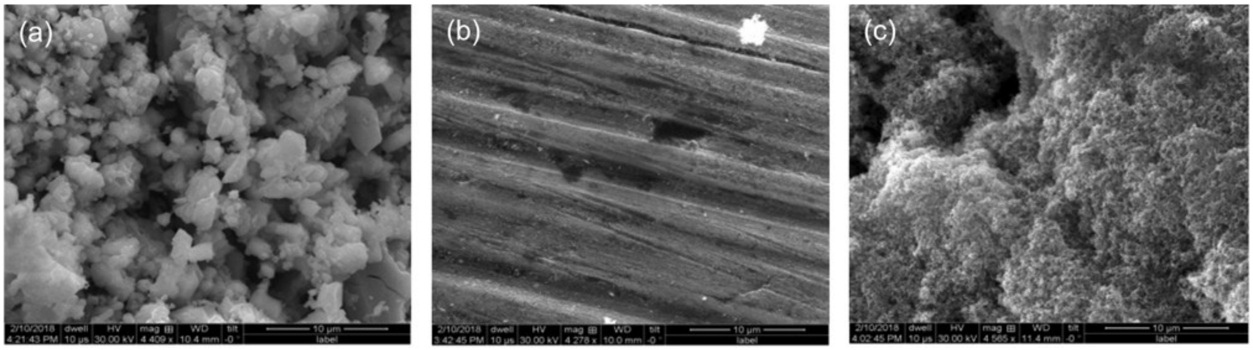

**Fig. S7.** SEM images from a control experiment involving copper electrodes in DI water only. (a) anode surface showed large granular deposits, while (b) the cathode looked clean and unchanged, and (c) the aggregate comprised of nanoscale particles. Scale bars = 10 μm.

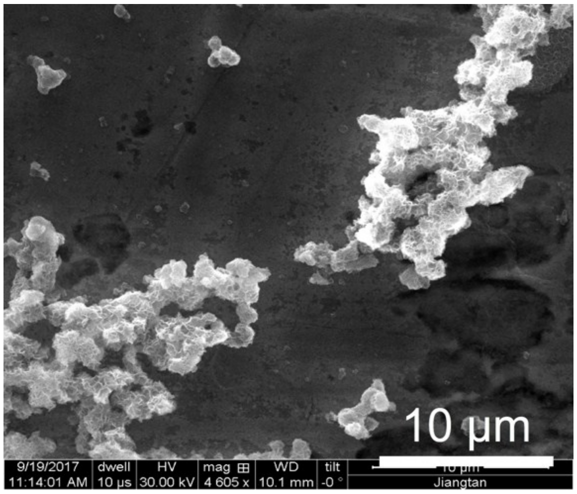

**Fig. S8.** SEM of the anode surface after anodic migration of a-SWCNTs. Scale bar = 10 μm.

**Fig. S9.** Photographs of an experiment involving copper electrodes ~~in~~ with a-SWCNTs (0.0034 mg.mL) in a $CuSO_4$ solution (0.1 mol/dm$^3$) after 709 s of electrolysis. The left electrode is the anode while the right electrode is the cathode.

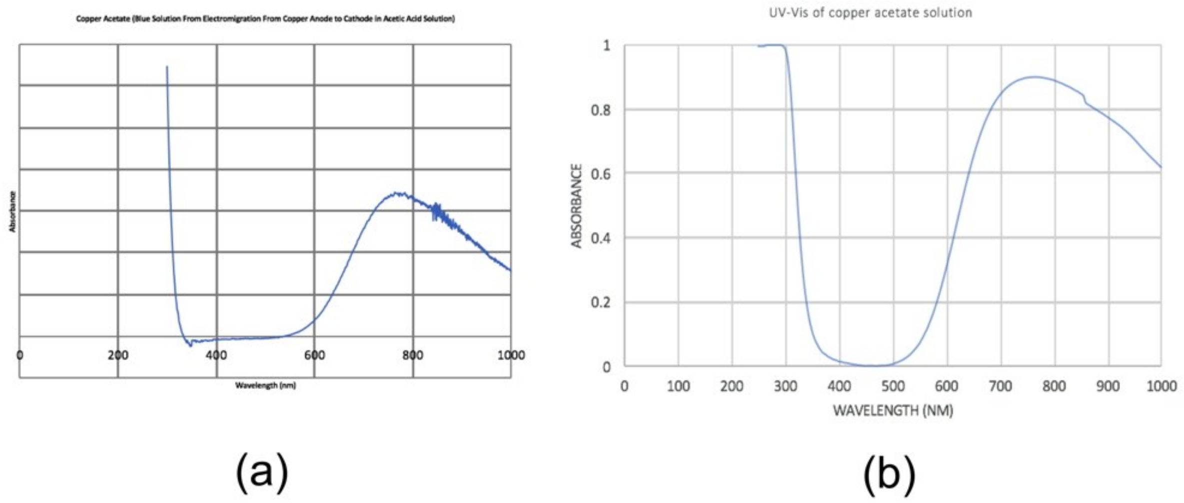

**Fig. S10.** UV-visible spectra of (a) blue-colored electrolytic bath shown in Fig. 18, and (b) copper acetate solution.

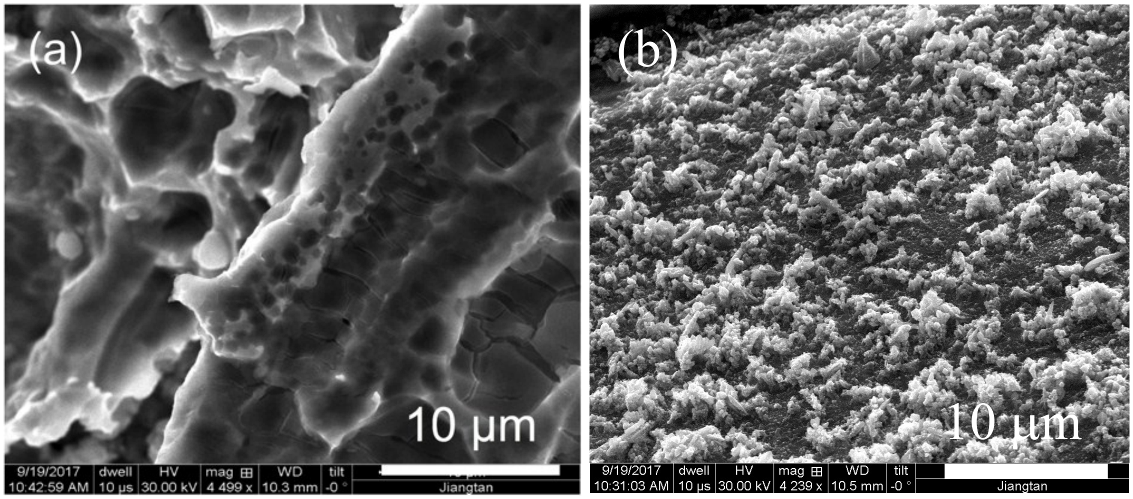

**Fig. S11.** SEM images of the copper (a) anode and (b) cathode surfaces after electrolysis of a solution of acetic acid (0.85 M). Scale bar = (a) 10 µm and (b) 100 µm.

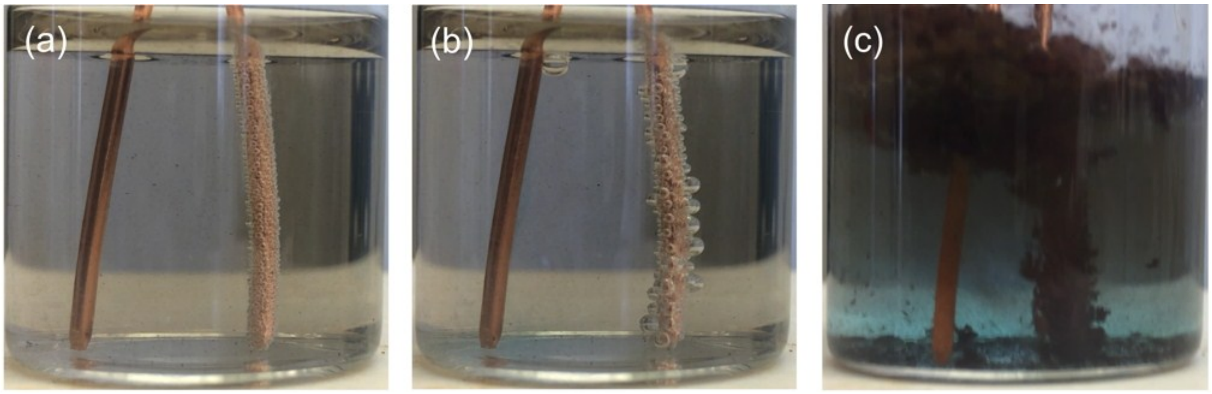

**Fig. S12.** Partitioning of a-SWCNTs between anode and cathode in experiment involving copper electrodes with a-SWCNTs (0.0034 mg/mL) in an acetic acid solution (0.85 mol/dm$^3$) upon addition of sodium EDTA (0.005 mol/dm$^3$): (a) 6 s, (b) 23 s, and (c) 931 s.

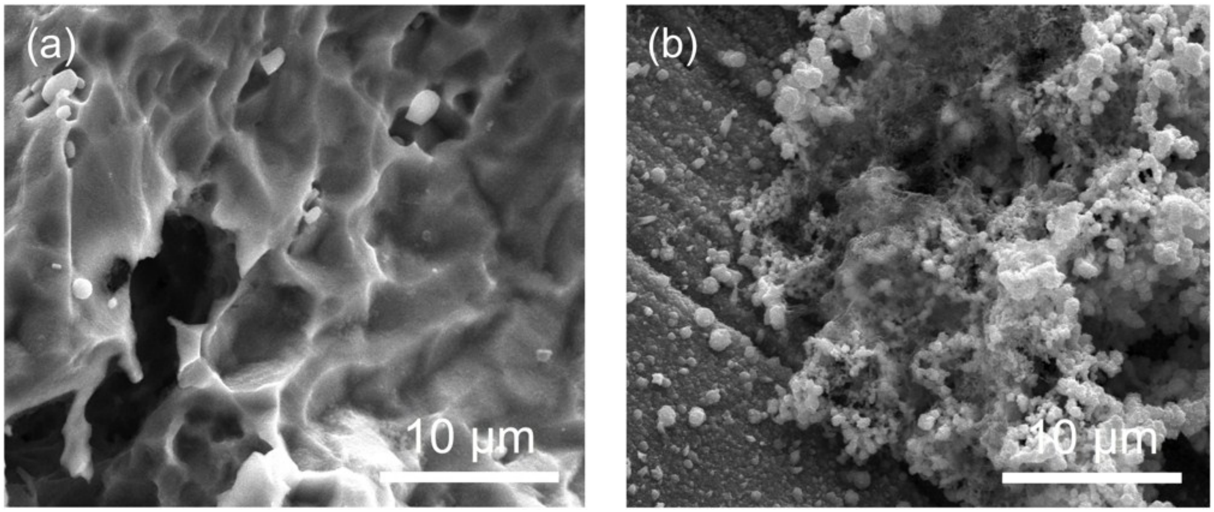

**Fig. S13.** SEM images of the copper (a) anode and (b) cathode surfaces after electrolysis of a-SWCNTs (0.0034 mg/mL) in an acetic acid solution (0.85 mol/dm$^3$) upon addition of sodium EDTA (0.005 mol/dm$^3$).

Suggested additional reading related to adsorption/desorption phenomena, and potential applications of metal-nanomaterial composites.

1 V. K. Gupta, R. Jain, A. Nayak, S. Agarwal, and M. Shrivastava, *Mater. Sci. Eng.: C.,* 2011, **31**, 1062-1067.

2 H. Khani, M. K. Rofouei, P. Arab, V. K. Gupta, and Z. Vafaei, *J. Hazard. Mater.,* 2010, **183**, 402-409.

3 V. K. Gupta, R. Kumar, A. Nayak, T. A. Saleh, and M. A. Barakat, *Adv. Colloid Interface Sci.*, 2013, **193-194**, 24-34.

4 R. Saravanan, E. Sacari, F. Gracia, M. M. Khan, E. Mosquera, and V. K. Gupta, *J. Mol. Liq.,* 2016, **221**, 1029-1033.

5 S. Rajendran, M. M. Khan, F. Gracia, J. Qin, and V. K. Gupta, *Sci. Rep.,* 2016, **6**, 1-11.

6 R. Saravanan, S. Joicy, V. K. Gupta, V. Narayanan, and A. Stephen, *Mater. Sci. Eng.: C.*, 2013, **33**, 4725-4731.

7 R. Saravanan, S. Karthikeyan, V. K. Gupta, G. Sekaran, V. Narayanan, and A. Stephen, *Mater. Sci. Eng.: C.*, 2013, **33**, 91-98.

8 R. Saravanan, E. Thirumal, V. K. Gupta, V. Narayanan, and A. Stephen, *J. Mol. Liq.,* 2013, **177**, 394-401.

9 R. Saravanan, V. K. Gupta, T. Prakah, V. Narayanan, and A. Stephen, *J. Mol. Liq.,* 2013, **178**, 88-93.

10 V. K. Gupta, and T. A. Saleh, *Environ. Sci. and Pollut. Res.,* 2013, **20**, 2828-2843.

11 M. Ahmaruzzaman, and V. K. Gupta, *Ind. Eng. Chem. Res.,* 2011, **50**, 13589-13613.

12 T. A. Saleh, and V. K. Gupta, *Sep. Purif. Technol.,* 2012, **89**, 245-251.

13 S. Karthikeyan, V. K. Gupta, R. Boopathy, A. Titus, and G. Sekaran, J. Mol. Liquids, 2012, **173**, 153-163.

14 R. Saravanan, N. Karthikeyan, V. K. Gupta, E. Thirumal, P. Thangadurai, V. Narayanan, and A. Stephen, *Mater. Sci. Eng.: C.,* 2013, **33**, 2235-2244.

15 R. Saravanan, M. M. Khan, V. K. Gupta, E. Mosquera, F. Gracia, V. Narayanan, and A. Stephen, *J. Colloid Interface Sci*., 2015, **452**, 126-133.

16 R. Saravanan, E. Thirumal, V. K. Gupta, V. Narayanan, and A. Stephen, J. Mol. Liq., 2013, **177**, 394-401.

17 M. Ghaedi, S. Hajjati, Z. Mahmudi, I. Tyagi, A. Maity, and V. K. Gupta, *Chem. Eng. J.,* 2015, **268**, 28-37.

18 V. K. Gupta, A. Nayak, S. Agarwal, and I. Tyagi, *J. Colloid Interface Sci*., 2014, **417**, 420-430.

19 D. Robati, B. Mirza, M. Rajabi, O. Moradi, I. Tyagi, S. Agarwal, and V. K. Gupta, *Chem. Eng. J.,* 2016, **284**, 687-697.

20 A. Asfaram, M. Ghaedi, S. Agarwal, I. Tyagi, and V. K. Gupta, *RSC Adv*., 2015, **5**, 18438 - 18450.

21 V. K. Gupta, N. Atar, M. L. Yola, Z. Ustundag, and L. Uzun, *Water Res.,* 2014, **48**, 210-217.