Supplementary Materials

Efficient and reusable graphene-γ-Fe_2O_3 magnetic nano-composite for selective oxidation and one-pot synthesis of 1,2,3-triazole using green solvent

Noor Salam,[a] Arjyabaran Sinha,[b] Paramita Mondal, Anupam Singha Roy, [a] Nikhil R. Jana [b,]*,

S. M. Islam[a,]*

[a]*Department of Chemistry, University of Kalyani, Kalyani, Nadia, 741235, W.B., India.*
[b]*Centre for Advanced Materials, Indian Association for the Cultivation of Science, Jadavpur, Kolkata 700 032, India.*

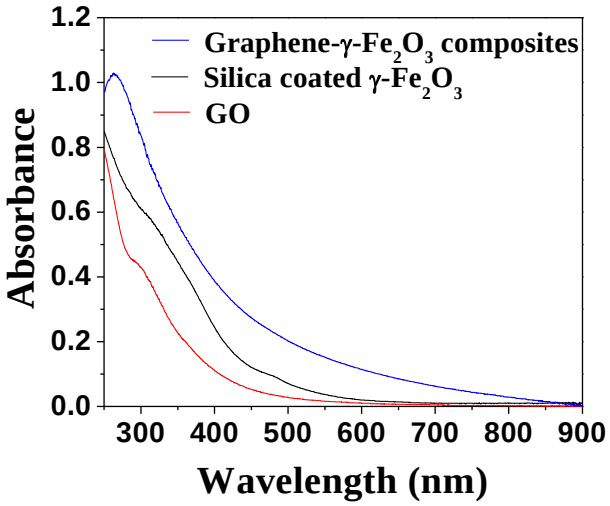

Figure S1. UV-Visible absorption spectra of graphene-γ-Fe_2O_3 composites, silica coated γ-Fe_2O_3 and graphene oxide.

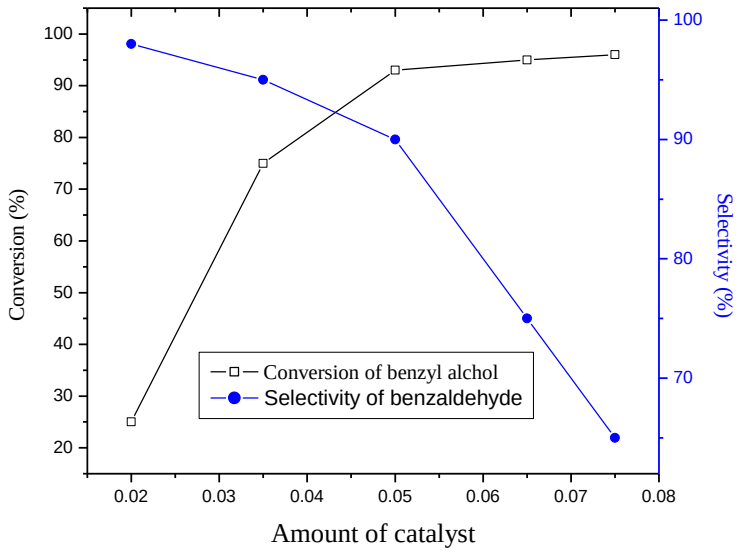

Figure S2. Effect of amount of catalyst on oxidation of benzyl alcohol as a function of time using graphene-γ-Fe_2O_3 composite

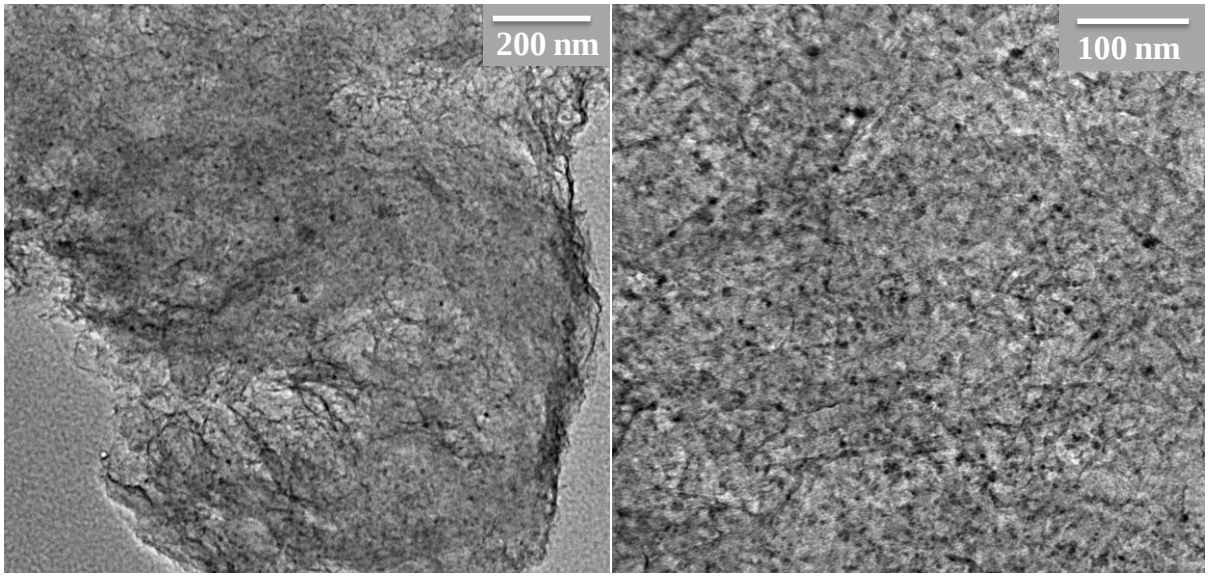

Figure S3: TEM image of reused Graphene-γ-Fe_2O_3 composite materials.

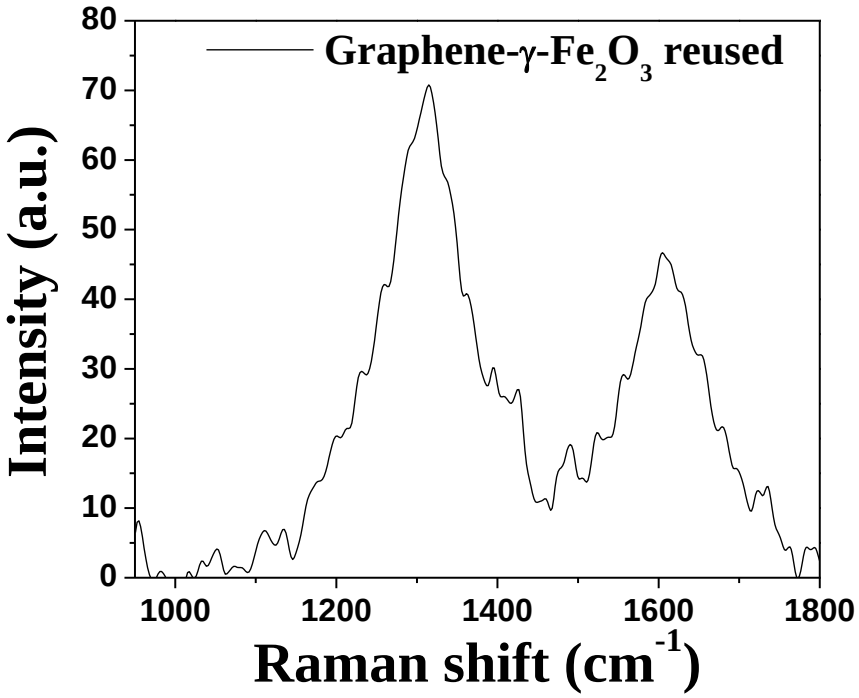

Figure S4: Raman spectra of Graphene-γ-Fe_2O_3 composite materials after reused showing two well documented D and G band at 1314 and 1604 cm^{-1}.

(c) Spectral data of the products

Spectral data of Bromination products

1. **5-Bromo-2-hydroxy benzaldehyde[1]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 10.80 (s, 1H, O*H*), 9.84 (s, 1H, C*H*O), 7.67 (d, 1H, Ar*H*), 7.56 (dd, 1H, Ar*H*), 6.88 (d, 1H, Ar*H*); ^{13}C NMR ($CDCl_3$) δ 195.6, 160.6, 139.6, 136.0, 121.8, 120.1, 111.7 ppm.
2. **4-Bromophenol[2]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 5.4 (s, 1H, O*H*), 6.75 (d, 2H, Ar*H*), 7.34 (d, 2H, Ar*H*); ^{13}C NMR ($CDCl_3$) δ 154.5, 132.8, 117.7, 112.5 ppm.

3. **4-Bromo-1, 3-dihydroxybenzene[1]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 7.24 (d, 1H, Ar*H*), 6.51 (d, 1H, Ar*H*), 6.36 (dd, 1H, Ar*H*), 5.49 (brs, 1H, O*H*), 4.80 (brs, 1H, O*H*); ^{13}C NMR ($CDCl_3$) δ 156.8, 154.1, 132.5, 110.1, 103.4, 98.3 ppm.

4. **2-Bromo-4-methylphenol[2]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 2.31 (s, 3*H*), 5.31 (s, 1H), 6.80 (d, 1H, Ar*H*), 7.02 (d, 1H, Ar*H*), 7.26 (d, 1H, Ar*H*); ^{13}C NMR ($CDCl_3$) δ 20.4, 110.1, 115.5, 118.1, 129.5, 132.7, 133.1, 150.1 ppm.

5. **2-Bromo-4-nitrophenol[3]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 6.19 (s, 1H, O*H*), 7.11 (d, 1H, Ar*H*), 8.09 (dd, 1H, Ar*H*), 8.44 (d, 1H, Ar*H*); ^{13}C NMR ($CDCl_3$) δ 159.4, 140.5, 126.1, 125.0, 118.8, 111.7 ppm.

6. **2-Bromo-4-aminophenol[4]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 5.11 (s, 1H, O*H*), 4.14 (s, 2H, NH_2), 6.43-6.54 (m, 3H, Ar*H*).

7. **4-Bromoanisole[1]:** ^{1}H NMR CDCl$_3$) δ (ppm) 3.81 (s, 3H, OCH_3), 7.35 (d, 2H, Ar*H*), 6.80 (d, 2H, Ar*H*); ^{13}C NMR (CDCl3) δ 159.1, 132.4, 116.4, 113.8, 55.7 ppm.

8. **2-Bromo-4-methylanisole[5]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 2.28 (s, 3H, CH_3), 3.86 (s, 3H, OCH_3), 6.82 (d, 1H, Ar*H*), 7.03 (dd, 1H, Ar*H*), 7.36 (d, 1H, Ar*H*).

9. **4-Bromoaniline[2]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 3.70 (brs, 2H, NH_2), 6.58 (d, 2H, Ar*H*), 7.25 (d, 2H, Ar*H*); ^{13}C NMR ($CDCl_3$) δ 110.1, 116.5, 132.3, 146.1 ppm.

10. **2-Bromo-4-nitroaniline[7]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 4.90 (brs, 2H, NH_2), 6.71 (d, 1H, Ar*H*), 8.01 (dd, 1H, Ar*H*), 8.35 (d, 1H, Ar*H*); ^{13}C NMR ($CDCl_3$) δ 150.1, 138.4, 129.3, 124.6, 113.6, 107.1 ppm.

11. **2-Bromo-4-methylaniline[8]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 2.24 (s, 3H, CH_3), 3.93 (brs, 2H, NH_2), 6.64 (d, 1H, Ar*H*), 6.90 (d, 1H, Ar*H*), 7.18 (s, 1H, Ar*H*); ^{13}C NMR ($CDCl_3$) δ 20.0, 108.8, 115.5, 129.3, 128.8, 132.7, 142.0 ppm.

12. **2-Bromo-4-chloroaniline[9]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 4.08 (s, 2H, N*H*$_2$), 6.64 (d, 1H, Ar*H*), 7.07 (dd, 1H, Ar*H*), 7.38 (d, 1H, Ar*H*); ^{13}C NMR ($CDCl_3$) δ 144.7, 130.8, 128.5, 123.6, 119.7, 115.4 ppm.

13. **4-Bromo-2-methylaniline[8]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 2.07 (s, 3H, C*H*$_3$), 3.56 (brs, 2H, N*H*$_2$), 6.47 (d, 1H, Ar*H*), 7.09 (d, 1H, Ar*H*), 7.14 (s, 1H, Ar*H*); ^{13}C NMR ($CDCl_3$) δ 17.7, 110.6, 116.4, 124.7, 129.5, 133.1, 143.8 ppm.

14. **4-Bromo-2-chloroaniline:** ^{1}H NMR ($CDCl_3$) δ (ppm) 6.44 (s, 2H, N*H*$_2$), 6.67 (d, 1H, Ar*H*), 7.44 (dd, 1H, Ar*H*), 7.88 (d, 1H, Ar*H*); ^{13}C NMR ($CDCl_3$) δ 143.0, 133.3, 132.5, 128.2, 120.6, 111.4 ppm.

15. **4-Bromo-2-nitroaniline[10]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 6.51 (s, 2H, N*H*$_2$), 6.70 (d, 1H, Ar*H*), 7.44 (dd, 1H, Ar*H*), 8.25 (d, 1H, Ar*H*); ^{13}C NMR ($CDCl_3$) δ 142.6, 138.7, 133.0, 128.10, 120.0, 109.5 ppm.

16. **4-Bromo-N, N-dimethylaniline[11]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 2.94 (s, 6H, C*H*$_3$), 6.67 (d, 2H, Ar*H*), 7.16 (d, 2H, Ar*H*); ^{13}C NMR ($CDCl_3$) δ 40.1, 108.10, 115.2, 131.9, 149.7 ppm.

Spectral data of Sulfides oxidation products

1. **Methylphenylsulfoxide[12]**: ^{1}H NMR ($CDCl_3$) δ (ppm) 2.72(s, 3H); 7.31-7.36(m, 1H); 7.41-7.48(m, 2H); 7.60-7.68(m, 2H); ^{13}C NMR ($CDCl_3$) δ 43.91; 123.50; 128.66; 130.99; 145.48

2. **Butylpropylsulfoxide[13]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 2.59-2.70 (m, 4H, CH_2) 1.67-1.73 (m, 4H, CH_2), 1.40-1.47 (m, 4H, CH_2), 0.91 (t, 6H, CH_3); ^{13}C NMR ($CDCl_3$) δ (ppm) 51.8, 24.6, 22.3, 13.7
3. **Diphenyl sulfoxide[14]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 7.58-7.63 (m, 4H), 7.38-7.43 (m, 6H); ^{13}C NMR ($CDCl_3$) δ (ppm), 145.7, 131.3, 129.0, 124.1
4. **Ethylphenyl sulfoxide[14]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 7.40-7.56 (m, 5H) 2.86-2.90 (m, 1H), 2.67-2.76 (m, 1H), 1.65 (t, 3H) ; ^{13}C NMR ($CDCl_3$) δ (ppm) 143.7, 131.6, 128.9, 124.6, 49.4, 7.0
5. **Cyclohexylphenyl sulfoxide[13]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 7.52-7.58 (m, 2H), 7.41-7.50 (m, 3H), 2.78 (t, 2H), 1.66-1.73 (m, 1H), 1.50-1.57 (m, 1H), 1.27-1.40 (m, 2H), 1.20-1.25 (m, 4H), 0.91 (t, 3H) ; ^{13}C NMR ($CDCl_3$) δ (ppm) 142.9, 130.3, 129.1, 123.7, 57.0, 31.3, 28.6, 22.4, 21.8, 14.1
6. **Benzylphenyl sulfoxide[13]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 7.386-7.42 (m, 5H) 7.17-7.23 (m, 3H), 6.90 (d, 2H), 4.11 (d, 1H), 3.98 (d, 1H); ^{13}C NMR ($CDCl_3$) δ (ppm) 143.1, 131.6, 130.2, 129.5, 128.4, 128.1, 127.8, 124.1, 63.5
7. **Phenyl (prop-1-ene) sulfoxide[13]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 7.86-7.91 (m, 2H), 7.58-7.62 (m, 1H), 7.47-7.52 (m, 2H), 5.70-5.80 (m, 1H), 5.28 (d, 1H), 5.14 (d, 1H), 3.75 (d, 2H) ; ^{13}C NMR ($CDCl_3$) δ (ppm) 138.5, 133.7, 129.4, 128.4, 124.6, 124.0, 60.2
8. **4-Methanesulfinyl benzonitrile[15]:** ^{1}H NMR ($CDCl_3$) δ(ppm) 2.74 (s, 3H), 7.73 (d, 2H), 7.80(d, 2H); ^{13}C NMR ($CDCl_3$) δ(ppm) 151.3, 132.8, 124.3, 117.5, 114.6, 43.6
9. **Methyl p-tolyl sulfoxide[15]:** ^{1}H NMR ($CDCl_3$) δ(ppm) 2.40 (s, 3H) , 2.72 (s, 3H) , 7. 30 (d, 2H), 7.52 (d, 2H); ^{13}C NMR ($CDCl_3$) δ(ppm) 142.2, 141.4, 130.0, 123.5, 43.7, 21.4

10. **Dimethyl sulfoxide[16]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 2.56 (s, 6H); ^{13}C NMR ($CDCl_3$) δ (ppm) 40.2
11. **Methyl(4-methoxyphenyl) sulfoxide[17]:** ^{1}H NMR ($CDCl_3$) δ (ppm)7.58 (d, 2H), 6.98 (d, 2H), 3.82 (s, 3H), 2.72 (s, 3H); ^{13}C NMR ($CDCl_3$) δ (ppm) 162.1, 136.3, 125.3, 114.7, 55.9, 39.8
12. **Di(n-propyl) sulfoxide[18]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 2.69–2.76 (m, 2H), 2.52–2.59(m, 2H), 1.81 (m, 4H), 1.12 (t, 6H); ^{13}C NMR ($CDCl_3$) δ (ppm) 54.4, 16.13, 13.46
13. **4-Nitro-methylphenyl sulfoxide[12]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 2.54 (s, 3H), 7.83 (d, 2H), 8.32(d 2H); ^{13}C NMR ($CDCl_3$) δ (ppm) 47.72, 124.4, 149.28, 153.2.
14. **2-Phenylsulfinylethanol[19]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 2.31 (s, 1H), 2.80-2.87 (m, 1H), 3.15-3.20 (m, 1H), 4.0-4.05(m, 1H), 4.15-4.21 (m, 1H), 7.50-7.55 (m, 3H), 7.62-7.65 (m, 2H) ^{13}C NMR ($CDCl_3$) δ (ppm)142.69, 130.7, 129.1, 123.6, 59.0, 55.8

Spectral data of Alcohol oxidation products

1. **Benzaldehyde[20]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 10.13 (s, 1H), 7.91 (d, 2H), 7.63 (m, 1H), 7.50 (m, 2H); ^{13}C NMR ($CDCl_3$) δ (ppm) 192.3, 136.0, 134.0, 130.2, 129.5.
2. **4-methoxy benzaldehyde[21]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 9.80 (s, 1H), 7.77 (d, 2H), 7.01 (d, 2H), 3.80 (s, 3H); ^{13}C NMR ($CDCl_3$) δ (ppm) 190.6, 164.4, 131.5, 129.8, 114.1, 55.4
3. **4-methyl benzaldehyde[21]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 9.98 (s, 1H), 7.73 (d, 2H), 7.31 (d, 2H), 2.40 (s, 3H); ^{13}C NMR ($CDCl_3$) δ (ppm) 192.1, 145.4, 134.0, 129.7, 129.6, 21.9
4. **4-bromo benzaldehyde[21]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 9.97 (s, 1H), 7.76 (d, 2H),7.66 (d, 2H); ^{13}C NMR ($CDCl_3$) δ (ppm) 191.1, 135.2, 132.2,130.9, 129.6

5. **2-methoxy benzaldehyde[21]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 10.45 (s, 1H), 7.80 (dd, 1H), 7.56 (td, 1H), 7.00-6.97 (m, 2H), 3.92 (s, 3H); ^{13}C NMR ($CDCl_3$) δ (ppm) 188.9, 161.4, 136.1, 128.4, 124.5, 120.5, 111.3, 55.8

6. **2,2-dimethyl-1-phenyl-1-propanone[22]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 7.57 (d, 2H), 7.20-7.48 (m, 3H), 1.25 (s, 9H); ^{13}C NMR ($CDCl_3$) δ (ppm) 209.8, 138.4, 131.0, 127.3, 127.61, 44.7, 28.3

7. **4-nitro benzaldehyde[23]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 10.16 (s, 1H), 8.39 (d, 2H), 8.07 (d, 2H); ^{13}C NMR ($CDCl_3$) δ (ppm) 192.4, 154.0, 143.7, 130.2, 124.1

8. **4-chloro benzaldehyde[20]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 10.14 (s, 1H), 7.80 (d, 2H), 7.63 (d, 2H); ^{13}C NMR ($CDCl_3$) δ (ppm) 191.1, 141.0, 134.6, 131.3, 129.9.

9. **1,2-diphenylethane-1,2-dione[24]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 7.92 (d, 4H,), 7.65-7.70 (m, 2H), 7.50-7.54 (m, 4H); ^{13}C NMR ($CDCl_3$) δ (ppm) 194.6, 134.5, 132.9, 130.0, 128.8

10. **Acetophenone:** ^{1}H NMR ($CDCl_3$) δ (ppm) 2.15 (s, 6H); ^{13}C NMR ($CDCl_3$) δ (ppm) 206.9, 31.1

11. **Benzophenone[22]:** ^{1}H NMR ($CDCl_3$) δ (ppm) 7.85 (d, 4H), 7.73 (m, 2H), 7.53 (m, 4H); ^{13}C NMR ($CDCl_3$) δ (ppm) 196.8, 138.1, 132.2, 129.9, 128.1.

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