Supporting Information

Facile, environmentally benign and scalable approach to produce pristine few layers graphene suitable for preparing biocompatible polymer nanocomposites

Gejo George¹, Suja Bhargavan Sisupal¹, Teenu Tomy¹, Alaganandam Kumaran¹, Prabha Vadivelu², Vemparthan Suvekbala¹, Swaminathan Sivaram³ and Lakshminarayanan Ragupathy¹*

¹Corporate R&D Center, HLL Lifecare Limited, Akkulam, Sreekariam (P.O), Trivandrum 695017, India
²CSIR-National Institute for Interdisciplinary Science and Technology, Industrial Estate (P.O), Pappanamcode, Trivandrum 695019, India
³Polymers and Advanced Materials Laboratory, National Chemical Laboratory, Dr. Homi Bhabha Road, Pune 411008, India

*Corresponding author:laks@lifecarehll.com, laks77@gmail.com

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S1 Planetary ball milling of graphite with curcumin/tetrahydrocurcumin/quercetin

The planetary ball mill used was a Restch PM400 with 4 grinding bowl fasteners. In a typical procedure 20 g of graphite was milled with 60 g curcumin/tetrahydrocurcumin/quercetin (1:3 ratio) and 2.5 g Darvan I (stabilizer) for 1 h at 100 rpm (15 min. grinding followed by 15 min. pause to avoid excessive heat production). Zirconia containers and zirconia balls were used for the ball milling procedure. After grinding, the samples are dispersed in water and sonicated for 2 min. at 25% amplitude using a 750 W sonicator.
S2 Characterization of exfoliated graphite (curcumin/tetrahydrocurcumin/quercetin as exfoliating agent) produced using planetary ball milling (solid phase exfoliation)

S2.1 XRD of quercetin exfoliated graphite

The XRD of Graphite:Quercetin:Darvan (1:3:0.125 before and after grinding) sample and graphite is shown in Figure S1.

Figure S1: Normalized XRD of graphite and graphene produced using quercetin as the exfoliating agent (ratios correspond to Graphite:Quercetin:Darvan).

S2.2 Raman spectra of curcumin/tetrahydrocurcumin/quercetin exfoliated graphite

The Raman spectra of Graphite:Quercetin:Darvan sample and graphite is shown in Figure S2. The shape of 2D band 1:3:0.125 Graphite:Quercetin:Darvan shows that the produced graphenes are about 10 layers \(1^{\text{st}}-3^{\text{rd}}\) thick.

Figure S2: Raman spectra of graphene samples produced using quercetin as the exfoliating agent.
The 2D band of all Graphite:Curcumin:Darvan samples is shown as Figure S3. Here again, a clear shift of the 2D band to the lower wavelength is visible. The shape of 2D band in 1:3:0.125 Graphite:Curcumin:Darvan shows that the produced graphenes are few layers\textsuperscript{1-5}. The zoomed in figures of D and 2D bands of 1:3:0.125 Graphite:Curcumin:Darvan are shown in Figure S4.

![Raman spectra of graphenes](image)

**Figure S3**: 2D band of graphite and graphite/curcumin sample milled at different ratios. The Darvan ratio is 0.125 in all the cases.

![Raman spectra of milled graphenes](image)

**Figure S4**: D and 2D bands of graphite and milled graphite/curcumin/Darvan (1:3:0.125) samples.

The 2D band of all Graphite:TetrahydroCurcumin:Darvan samples is shown as Figure S5. Here again, a clear shift of the 2D band to the lower wavelength is visible. The shape of 2D band
1:3:0.125 Graphite:TetrahydroCurcumin:Darvan shows that the produced graphenes are few layer\textsuperscript{1-3}.

Figure S5: 2D band of graphite and graphite/tetrahydrocurcumin/darvan sample milled at different ratios. The ratios correspond to Graphite:tetrahydrocurcumin:darvan.

The deconvolution of the 2D band in 1:3:0.125 Graphite:Curcumin:Darvan sample leads to four lorentzian peaks at 2666.31, 2688.46, 2708.88 and 2725.91 cm\textsuperscript{-1} and the deconvolution of 2D band of the 1:3:0.125 Graphite:TetrahydroCurcumin:Darvan yields four lorentzian peaks appearing at 2664.87, 2684.26, 2701.85 and 2721.23 cm\textsuperscript{-1}. $I_D/I_D'$, $I_D/I_G$ and in-plane crystallite sizes, $L_a$ of graphene samples prepared are given in Table S1.

Table S1. $I_D/I_D'$, $I_D/I_G$ and in-plane crystallite sizes, $L_a$ of graphene samples prepared using different exfoliating agents.

| S. No | Sample details | $I_D/I_D'$ | $I_D/I_G$ | $L_a$(nm) |
|-------|----------------|------------|-----------|-----------|
| 1.    | Graphite:Curcumin:Darvan(1:3:0.125) | 0.85, 1.23, 1.09 | 0.54, 0.45, 0.40 | 28, 37, 41 |
| 2.    | Graphite:Tetrahydrocurcumin/Darvan (1:3:0.125) | 0.97, 0.74, 0.81 | 0.28, 0.21, 0.35 | 59, 79, 47 |
| 3.    | Graphite:Quercetin:Darvan(1:3:0.125) | No. of graphene layers is 10, therefore, $D'$ peak is not observed here. | 0.17, 0.10, 0.21 | 98, 167, 79 |
S2.3 TEM analysis

The TEM images of 1:3:0.125 Graphite:Quercetin:Darvan sample is shown as Figure S6. The images clearly show that the produced graphene is multilayered (≥ 5) evidenced by the reduced transparency of the graphene sheets.

![TEM images of 1:3:0.125 Graphite:Quercetin:Darvan sample.](image)

Figure S6: TEM images of 1:3:0.125 Graphite:Quercetin:Darvan sample.

S3 Characterization of exfoliated graphite produced using planetary ball milling (solution phase exfoliation)

S3.1 XRD

![XRD of graphite, curcumin and Graphite:Curcumin:Darvan (mixture) samples with varying solvent ratios.](image)

Figure S7: XRD of graphite, curcumin and Graphite:Curcumin:Darvan (mixture) samples with varying solvent ratios.
The normalized XRD spectrum of graphite, curcumin & Graphite:Curcumin:Darvan samples with varying solvent ratios (acetone:water) is shown as Figure S7.

**S3.2 Raman Spectra**

The Raman spectra of Graphite:Curcumin:Darvan samples prepared using different solvent ratios (acetone:water) are shown as Figure S8. This demonstrates that in the case of Graphite:Curcumin:Darvan with 50:50 (acetone: water) mixture the graphene produced is a bi-layer whereas in other solvent ratios it is found to be approximately 5 layers (2D band deconvolutes into 2 Lorentzian peaks)\(^1-^3\). \(I_D/I_D', I_D/I_G\) and in-plane crystallite sizes, \(L_a\) of graphene samples prepared using 50:50 (acetone: water) solvent mixture Graphite:Curcumin:Darvan is shown as Table S2.

![Figure S8: Raman spectra of Graphite:Curcumin:Darvan (mixture) samples with varying solvent ratios (acetone: water).](image-url)
Table S2. $I_D/I_D'$, $I_D/I_G$ and in-plane crystallite sizes, $L_a$ of graphene samples prepared using wet grinding method in 50:50 wt% acetone:water using curcumin.

| S. No. | Sample details                     | $I_D/I_D'$       | $I_D/I_G$           | $L_a$ (nm) |
|--------|------------------------------------|------------------|---------------------|------------|
| 1.     | Graphite:Curcumin:Darvan (1:3:0.125) | 0.88, 0.92, 1.12 | 0.16, 0.20, 0.23    | 104, 83, 73 |

$I_D/I_D'$ values clearly indicates that no new defects are introduced into the graphene samples during the grinding process.

**S3.3 TEM analysis**

TEM images of Graphite:Curcumin:Darvan (50:50 acetone:water) system with 1:3:0.125 ratio is shown as Figure S9.

![TEM images](image)

(a) ![TEM images](image) (b)

Figure S9: TEM images of (a) & (b) Graphite:Curcumin:Darvan (50:50 acetone: water) sample and c) SAED pattern

**S4 Characterization of exfoliated graphite produced using sand grinder**

**S4.1 XRD**

The normalized XRD of graphite and Graphite:Curcumin:Darvan (1:3:0.125) sample produced using sand grinding technique is shown as Figure S10.
Figure S10: Normalized XRD of graphite and Graphite:Curcumin:Darvan (1:3:0.125 wt. ratio) sample produced using sand grinding technique.

**S4.2 Raman Spectra**

The Raman spectra of graphite and graphene (Graphite:Curcumin:Darvan, 1:3:0.125) produced using sand grinding process, along with the deconvolution of 2D band is shown as Figure S11 and the corresponding $I_D/I_G$ ratios in table S3.

Figure S11: Raman spectra of graphite and Graphite:Curcumin:Darvan (1:3:0.125) sample produced using sand grinder and the deconvoluted 2D band.
Table S3. $I_D/I_D' , I_D/I_G$ and in-plane crystallite sizes, $L_a$ of graphene samples prepared using sand grinder.

| S. No. | Sample details                      | $I_D/I_D'$ | $I_D/I_G$ | $L_a$ (nm) |
|--------|-------------------------------------|------------|-----------|------------|
| 1.     | Graphite:Curcumin:Darvan (1:3:0.125)| 0.78, 0.55,| 0.11, 0.10,| 152, 167, 335 |
|        |                                     | 0.48       | 0.05      |            |

S.4.3 TEM analysis

The TEM images of Graphite:Curcumin:Darvan sample (1:3:0.125) produced by sand grinding technique is shown as Figure S12.

Figure S12: (a) & (b) TEM images of Graphite:Curcumin:Darvan (1:3:0.125) samples produced by sand grinding and (c) SAED pattern of the graphene sheet.
S5. Table S4. Toxicity of graphene exfoliating agents/chemicals/salts etc.

| S. No. | Exfoliation Method/agent | Reported no. of layers | Graphene production rate(yield) in g/hr | D/G Ratio | Toxicity |
|--------|--------------------------|------------------------|--------------------------------------|-----------|----------|
|        |                          |                        |                                      |           | Oral toxicity | Skin toxicity | Chronic toxicity |
| 1      | Solid-phase: (a) Ball milling with Curcumin (Current work, solid-phase exfoliation, solution-phase exfoliation). (b) sand Grinding with Curcumin | 2-10                   | (a) 45.7 (solid-phase), 20 (solution-phase). (b) 10 (sand grinding). | (a) 0.40-0.54 (solid-phase), 0.16-0.23 (solution-phase). (b) 0.05-0.11 (sand grinding). | LD50 Oral-Mouse- > 2,000 mg/kg. LD50 Oral-Rat- > 2,000 mg/kg. | Slightly hazardous in case of skin contact (irritant). | Curcumin, administered before or after radiation, markedly reduced acute and chronic skin toxicity in mice (p < 0.05). |
| 2      | Solid-phase: Ball milling with Tetrahydrocurcumin (Current work) | 2-10                   | 45.7 | 0.21-0.35 | LD50 Oral-Mouse- 300 mg/kg. LD50 Oral-Rabbit-3200 mg/kg. LD50 Oral-Rat- 980 mg/kg. | | |
| 3      | Solid-phase: Ball milling with Quercetin and (Current work) | 10 | 45.7 | 0.10-0.21 | LD50 Oral-Rat- 161 mg/kg. | | |
| 4      | Solution-phase: Shear exfoliation with N-methylpyrrolidone, aqueous solutions of sodium cholate and polyvinyl alcohol (PVA) | Few layers | 5.3 | 0.17-0.37 | N-methylpyrrolidone LD50 Oral-Rat- 3,914 mg/kg. | Sodium cholate - PVA LD50 Oral-Rat- > 20,000 mg/kg. | N-methylpyrrolidone LD50 Dermal-Rabbit-8,000 mg/kg. | |
| 5 | **Solid-phase:** Ball milling with Melamine\(^1,^6\). | Few layers | 0.015\(^1\) and 22.9\(^6\) | 0.41-0.49 \(\text{LD}_{50}\) Oral-Rat-male- 3,161 mg/kg.\(^61\) | \(\text{LD}_{50}\).Dermal - Rabbit - > 1,000 mg/kg.\(^{11}\) No skin irritation. \(^61\) Acute dermal toxicity in rabbits presents when the exposure is 1g/kg body wt.\(^{52}\) | Long-term exposure to melamine reduces fertility and results in fetal toxicity in animal studies. The most commonly reported chronic renal toxicity is stone formation.\(^{62}\) |
|---|---|---|---|---|---|---|
| 6 | **Solution-phase:** Wet stirred media milling with sodium dodecyl sulfate\(^7\). | Single to Multilayer s | 1.5-2.5 | \(\sim0.6-0.7\) (532nm) | \(\text{LD}_{50}\) Oral-Rat-male and female- 1,200 mg/kg.\(^63\) | Skin irritation (Rabbit 24 h OECD Test Guideline 404).\(^63\) In animal studies SDS appears to cause skin and eye irritation.\(^{64}\) SDS may worsen skin problems in individuals with chronic skin hypersensitivity.\(^{64}\) |
| 7 | **Solution-phase:** CVD with sodium ethoxide\(^8\). | Few (4) layers | 1 | \(\sim1\) (532 nm) | \(\text{LD}_{50}\) Oral-Rat-male and female - 598 mg/kg (OECD Test Guideline 401).\(^65\) | Causes severe burns on skin (Rabbit -3 min OECD Test Guideline 404).\(^15\) Create redness, pain blisters and skin burns.\(^{66}\) |
| 8 | **Solution-phase:** KI intercalation with acid (HNO\(_3\) and H\(_2\)SO\(_4\)) - intercalated/ exfoliated graphite\(^9\). | 30-40 | 0.9 g | No Raman | \(\text{LD}_{50}\) Intraperitoneal-Mouse- 700 mg/kg.\(^{67}\) | Exposure to radiation can damage the basal cell layer of skin, resulting in inflammation, erythema, and dry or moist desquamation.\(^{68}\) |
| 9 | **Solution-phase:** Interlayer | 1-3 | 0.4 g | No Raman | \(\text{FeCl}_2\) \(\text{LD}_{50}\) Oral-Rat- No skin | \(\text{FeCl}_2\) No skin | \(\text{H}_2\text{O}_2\) Material is |
| Solution-phase: | catalytic exfoliation with FeCl₂ and H₂O₂. |  |  |  |  |
|----------------|---------------------------------------------|  |  |  |  |
| 10             | Solution-phase: Na in liquid NH₃ Reduction | 1  | 0.33 g  | ~ 1.4 (514 nm) | Ammonia LC₅₀ Inhalation - Rat -4h - 2000 ppm. LC₅₀ Rabbit inhalation 7,050 mg/cu m/1 hr. LD₅₀ Rat oral 350 mg/kg. LD₅₀ Mouse inhalation 4,837 ppm/1 hr. | Ammonia The vapor even in low concentration is extremely irritating to skin, eyes and respiratory passages. Ammonia Exposures of 500 ppm for 30 min have caused upper respiratory irritation, tearing, increased pulse rate, and blood pressure. |
| 11             | Solution-phase: Exfoliation with chlorosulfonic acid and H₂O₂ | Few layers (3) | ~0.25 g | 0 (514 nm) | chlorosulfonic acid LC₅₀ mouse inhalation 52.5 mg/cu m/2 hr. LC₅₀ rat inhalation 38.5 mg/cu m/4 hr. | chlorosulfonic acid Highly irritating & corrosive to eyes, skin, mucous membranes. |
| 12             | Solution-phase: Sonication of expanded graphite with 1-pyrenesulfonic acid sodium salt (Most effective one) | Few layer | 0.02 | ~0.33 | - | - | - |
| 13 | **Solution-phase:** Sonication with Isopropanol. | 1-5 | ~ 0.015 | 0.2-0.4 (633 nm) | LD₅₀ Oral-Rat-5,045 mg/kg Remarks: Behavioral: Altered sleep time (including change in righting reflex). Somnolence (general depressed activity). LC₅₀ Inhalation-Rat- 8 h - 16000 ppm. | Mild skin irritant. LD₅₀ Dermal - Rabbit - 12,800 mg/kg. | Repeated exposures produced toxic effects only at the highest concentration (5000 ppm) and a kidney change in male rats of unknown biological significance. |
| 14 | **Solution-phase:** Horn ultrasonication of naturally occurring graphite flakes with bile salt sodium cholate. | Few layers | 0.018 | - | - | - | - |
| 15 | **Solution-phase:** Sonication with N-Methyl-2-pyrrolidone (NMP) and thermal treatment. | 1-4 | <0.01 | < 0.15 (514 nm) | LD₅₀ Oral-Rat- 3,914 mg/kg LDLo Inhalation -Rat - 4 h - > 5100 ppm. | LD₅₀ Dermal - Rabbit - 8,000 mg/kg. | The no-observed-effect level for NMP was 5000 ppm for male and female rats, 600 ppm for male mice, and 1200 ppm for female mice. |
| 16 | **Solution-phase:** Intercalation of alkali metal (ternary KCl-NaCl-ZnCl₂eutectic system) between graphite Interlayers. | Few layers (18% of are single/double layer) | 0.012 | 0.15 (514 nm) | - | - | - |
| 17 | **Solution-phase:** Sonication with Gum Arabic (biopolymer). | 5-20 | ~6×10⁻³ | ~0.25 (633 nm), | LD₅₀ Oral-Rat- > 16,000 mg/kg. | - | - |
| Solution-phase | Grinding with ionic liquids (1-Butyl-3-methylimidazolium hexafluorophosphate)\(^{19}\) | 2-5 | 0.01 | 0.23 (514 nm) | - | - | - |
| Solution-phase | Dissolution in superacids (chlorosulphonic acid)\(^{20a,20b}\) | Single (70%) | \(\sim 4.2 \times 10^{-3}\) | 0.1-0.5 (514 nm) | LC\(_{50}\) mouse inhalation 52.5 mg/cu m/2 hr.\(^{84}\) | Highly irritating & corrosive to eyes, skin, mucous membranes.\(^{85}\) | - |
| Solution-phase | Sonication in Cyclohexanone\(^1\)\(^2\) | Few | \(3 \times 10^{-3}\) | No Raman | LD\(_{50}\) Oral-Rat-12,705 mg/kg LC\(_{50}\) Inhalation-Rat-4 h-34,000 mg/l (OECD Test Guideline 403) LD\(_{50}\) Dermal-Rabbit - > 2,000 mg/kg.\(^{86}\) | No skin irritation.\(^{86}\) | Chronic or repeated exposure can result in skin irritation due to defatting of the skin.\(^{87}\) |
| Solution-phase | Sonication with Sodium dodecylbenzenesulfonate.\(^{22}\) | Few layers (>40% and Mono layer (~3%) | \(2.5 \times 10^{-3}\) | 0 on thick films (large FLG), ~0.4 on thin films (small flakes), 532 nm | LD\(_{50}\) Oral-Rat-438 mg/kg.\(^{88}\) | Skin irritant.\(^{88}\) | - |
| Solution-phase | Sonication with vinylcaprolactam.\(^{23}\) | Few layers (5-7) | \(2.1 \times 10^{-3}\) | \(\sim 0.14\) (532 nm), 0.1 in powder | LD\(_{50}\) Oral- Rat-male/female1.8 60 mg/kg.\(^{89}\) | LD\(_{50}\) Dermal-Rabbit-male and female - 1,700 mg/kg (OECD Test Guideline 402).\(^{90}\) | Repeated exposure to small quantities may affect certain organs. Damage to the liver.\(^{89}\) |
| Solution-phase | Grinding with Ionic liquid (1-hexyl-3-methylimidazolium hexafluorophosphate) followed by sonication | Few layers | $2.2 \times 10^{-3}$ | ~0.14 (532 nm), 0.1 in powder | - | Causes skin irritation. |
|----------------|-------------------------------------------------------------------------------------------------|-----------|---------------------|---------------------------|---|--------------------------|
| Solution-phase | Sonication with sodium chlorate surfactant | Bi and Multi layers | $2 \times 10^{-3}$ | 0 (488 nm) | LD<sub>50</sub> Rat-1200 mg/kg | Hazardous in case of skin contact (irritant) |
| Solution-phase | High-shear mixing with orthodichlorobenzene and (DCB) sonication | Few layers (<5) | $2.0 \times 10^{-3}$ | <0.3 (514 nm) | LD<sub>50</sub> Rat-oral 1516-2138 mg/kg, LD<sub>50</sub> Mouse-oral 2000 mg/kg | The air concentration level of 1,2-DCB where irritation to humans begins (threshold of irritation), was found to be 0.15 mg/L |
| Solution-phase | Sonication with 1-pyrene carboxylic acid | Single, few and multilayered graphene | $<1.7 \times 10^{-3}$ | ~0.15 (532 nm) | - | - |
| Solution-phase | Sonication with diisocyanates | Few layers | $1.6 \times 10^{-3}$ | 0.2-0.3 (532 nm), 0.11 in powder | LD<sub>50</sub> Mouse-oral 196 mg/kg, LD<sub>50</sub> Rat-oral 940 mg/kg | LD<sub>50</sub> Rat-(male) dermal 5000 uL/kg, LD<sub>50</sub> Rabbit skin 7130 mg/kg |
| Solution-phase | ICl and IBr Intercalation | 2-3 layers | $<1 \times 10^{-3}$ | <0.2 (633 nm) | - | ICI Can irritate the lungs, repeated exposure may cause bronchitis to develop with cough phlegm |

Causes skin irritation. 
Hazardous in case of skin contact (irritant).
The air concentration level of 1,2-DCB where irritation to humans begins (threshold of irritation), was found to be 0.15 mg/L.
ICI Can irritate the lungs, repeated exposure may cause bronchitis to develop with cough phlegm.
| Solution-phase                                                                 | No. of layers | Log10 Concentration | LD_{50} Oral/Rat | LD_{50} Mouse | LD_{50} Rat-oral | LD_{50} Skin and eye irritation | LD_{50} Isopropanol | LD_{50} CHCl{3} | Result | Route | Toxicity |
|-------------------------------------------------------------------------------|--------------|---------------------|-------------------|---------------|-----------------|-------------------------------|---------------------|---------------|--------|-------|----------|
| Wet ball milling with N,N-dimethylformamide (DMF)                              | ≥3 layers    | 0.34                | 2,800 mg/kg       | 3000 mg/kg    | 10.7 mL/kg      | -                            | -                                 | -               |        |         |
| Oral-Rat 2,800 mg/kg                                                         | ≤3 layers    | 0.25 (514 nm)       | 9,800 mg/kg       | 3000 mg/kg    | 10.7 mL/kg      | -                            | -                                 | -               |        |         |
| Inhalation 4h-9-15 mg/l                                                        | <5 layers    | 0.35                | -                 | -             | -               | -                            | -                                 | -               |        |         |
| Skin – Human Result: Mild skin irritation - 24 h                               | <5 layers    | 0.35                | -                 | -             | -               | -                            | -                                 | -               |        |         |
| Repeated exposure to 25-920 ppm: results chronic conjunctivitis, pharyngitis, bronchitis, gastritis, and gastroduodenitis. | 2-3 layers   | 0.35                | -                 | -             | -               | -                            | -                                 | -               |        |         |
| Sonication with quinquethiophene-terminated poly(ethylene glycol) (nonionic surfactant) | 10 layers    | 3.1x10^-4           | < 0.4 (633 nm); starting powder 0.14 | -             | -               | -                            | -                                 | -               |        |         |
| Sonication with low boiling point solvents (CHCl{3} and isopropanol)          | 2x10^-4      | Not given            | -                 | -             | -               | -                            | -                                 | -               |        |         |
| Stirring with KC{8} in NMP                                                    | Few layers   | 2x10^-4             | -                 | -             | -               | -                            | -                                 | -               |        |         |
| Sonication with hexadecyltrimethyl ylammonium bromide/acetic acid             | Few layers   | 1.9x10^-4           | ~ 0.2 (532 nm)    | -             | -               | -                            | -                                 | -               |        |         |
|   | **Solution-phase:** | Few layers and single layer | Estimated from spectra: 0.4-0.6 (532 nm) |   |
|---|----------------------|-----------------------------|------------------------------------------|---|
| 35 | Ultra sonication with perylenebisimide-Based Bolaamphiphile | - | SDS | 35 |
| 36 | Sonication with surfactants [sodiumdodecyl sulfate (SDS), dodecylbenzenesulfonic acid (SDBS), lithium dodecyl sulfate (LDS), cetyltrimethyl ammoniumbromide (CTAB), tetradecyltrimethy lammonium bromide (TTAB), sodium cholate (SC), sodium deoxycholate (DOC), IGEPAL CO-890, Triton X-100, Tween 20 and Tween 80 sodiumtaurodeoxycholate (TDOC)] | 1-16 layers | SDS | 35 |
|   |   |   |   |   |
|   |   | 1-16 layers | 5 × 10⁻³ | 0.25-0.6 |   |
|   | SDS | LD₅₀ Oral-Rat-male and female-1,200 mg/kg.¹⁰⁴ |   | SDS | Skin irritant.¹⁰⁴ |
|   | SDBS | LD₅₀ Oral-Rat-650 mg/kg.¹⁰⁵ |   | SDBS | Skin irritant.¹⁰⁵ |
|   | CTAB | LD₅₀ Oral-Rat-410 mg/kg.¹⁰⁶ |   | CTAB | Moderate skin irritant.¹⁰⁶ |
|   | TTAB | LD₅₀ Oral-Rat-male and female-390 mg/kg.¹⁰⁷ |   |   |   |
|   | SC |   |   | SC |   |
|   | DOC | LD₅₀ Oral-Rat-1,370 mg/kg. LD₅₀ Oral-Mouse-1,050 mg/kg.¹⁰⁸ |   | DOC |   |
|   | IGEPAL CO-890 | LD₅₀ Oral-Rat-4,000 mg/kg.¹⁰⁹ |   | IGEPAL CO-890 | Irritating to skin.¹⁰⁹ |
|   | Triton X-100 |   |   | Triton X-100 |   |
|   | Tween 20 | LD₅₀ Oral-Rat-40,554.0 mg/kg.¹¹⁰ |   | Tween 20 | Mild skin irritation.¹¹⁰ |
|   | Tween 80 |   |   | Tween 80 |   |
| Solution-phase | Few layers | ~3.9×10⁻³ | No data available | LD₅₀ Oral-Rat-813 mg/kg.¹¹² | LD₅₀ Dermal-Rabbit-> 3,000 mg/kg.¹¹² |
|----------------|------------|-----------|-------------------|-----------------------------|----------------------------------|
| Solution-phase: Sonication with Tetraethylene glycol diacrylate³⁸. | Few layers | ~3.9×10⁻³ | No data available | Phenyl triethoxysilane LD₅₀ Oral-Rat-2,734 mg/kg.¹¹³ | Phenyl triethoxysilane LD₅₀ Dermal-Rabbit-3,167 mg/kg.¹¹³ |
| Solution-phase: Sonication of nanoribbons in hypophosphorous acid³⁹. | Multi layers | ~3.3×10⁻³ | No data available | 3-glycidoxypropyl trimethoxysilane LD₅₀ Oral-Rat-8,030 mg/kg.¹¹⁴ | 3-glycidoxypropyl trimethoxysilane LD₅₀ Dermal-Rabbit-4,248 mg/kg.¹¹⁴ |
| Solution-phase: Sonication with organosilanes (Phenyl triethoxysilane and 3-glycidoxypropyl trimethoxysilane)⁴⁰. | Few layers | 3.3×10⁻³ | 0.65 (532 nm) | FeCl₃ LD₅₀ Oral-Mouse-1,300 mg/kg.¹¹⁵ | FeCl₃ LD₅₀ Dermal-Rabbit- > 2,000 mg/kg.¹¹⁵ |
| Solution-phase: Microwave assisted exfoliation of FeCl₃ and CH₃ NO₂ co-intercalated graphite.⁴¹ | Multilayers | 1.6×10⁻³ | 0 but layer graphenes (~5) | CH₃ NO₂ LD₅₀ Oral-Rat-male and female-1,478 mg/kg.¹¹⁵ | - |
| Solution-phase | Handling Method | Minimum Layer Count | Maximum Layer Count | 5th percentile (514 nm) | 50th percentile (514 nm) | 95th percentile (514 nm) | Note |
|----------------|----------------|---------------------|---------------------|-------------------------|-------------------------|------------------------|-------|
| 41             | Sonication with N-Methylpyrrolidone | Single, bi and few layers/few layers (<5)/~3-4 layers/monolayer (7-12 wt.%) | ~1.2×10^{-7}/1.3×10^{-3}/9×10^{-4}/1.5×10^{-4}/2×10^{-4} | <0.25 for bath, <0.35 for tip (<633 nm)/0.25-2.5 (457, 514, 633 nm)/<0.36/<0.5 (633 nm)/0 is thick films and 0.2 is for thin films | LD_{50} Oral-Rat-3,914 mg/kg. | LD_{50} Dermal-Rabbit-8,000 mg/kg. | - |
| 42             | Sonication with surfactants (sodium cholate hydrate, didodecyldimethyl lammonium bromide, and Triton X-100) | Few layers | 1.2×10^{-3} | 0.45 (514 nm) | - | - | - |
| 43             | Sonication with non-ionic block copolymers (Pluronics and Tetronics) | 1 to ~10 layers | 1.1×10^{-3} | 0.9 (514 nm) | - | - | - |
| 44             | Exfoliation in ionic liquid (1-butyl-3-methyl-imidazolium bis(trifluoromethanesulfonylimide) | Single, bi, few and multi layers | 9.5×10^{-4} | 0.17 | LD_{50} Oral-Rat->50 <- 300 mg/kg. | - | May cause damage to organs through prolonged or repeated exposure. |
| 45             | Sonication with sodium cholate | 1-10 layers (20% is monolayer) | 3×10^{-4} | 0.57 (633 nm) | - | - | - |
| 46             | Graphene sheets were made from natural graphite | Few layers | 1.4×10^{-5} (chemical exfoliation) and 5×10^{-4} | 1 (633 nm) | DMF LD_{50} Oral-Rat-2,800 mg/kg. | LC_{50} Inhalation-DMF Mild skin irritation. | - |
| Solution-phase | 1-3 layers (60% are single layer) | ~7.6×10⁻⁶ | Not given | DOC LD₅₀ Oral-Rat-1,370 mg/kg. LD₅₀ Oral-Mouse-1,050 mg/kg. |
| Solution-phase | Few layers (mostly ≤3 layers) | - | Spectrum is poor and cannot be detected | DCE LD₅₀ Oral-Rat-670.0 mg/kg. |
| Solution-phase | 15, 30, 37 and 18% of the GNSs comprised 2-3, 4, 5-10 and >10 layers of graphene, respectively. | 0 (633 nm) | - | - |
| 50 | **Solution-phase:** Electrochemical exfoliation with LiCl/propylene carbonate<sup>51</sup> | < 5 layers | ~0.25 | 0 (514) | LiCl - Propylene carbonate LD<sub>50</sub> Oral-Rat-> 5,000 mg/kg. | - Propylene carbonate LD<sub>50</sub>Dermal-Rabbit-> 2,000 mg/kg. | - |
| 51 | **Solution-phase:** K(THF)<sub>x</sub>C<sub>24</sub> (THF = tetrahydrofuran, x = 1-3)<sup>52</sup> | Multi layers | - | >1 | - | - | - |
| 52 | **Solution-phase:** Methods produced through GO (e.g. Concentrated Sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) (a) in combination with fuming Nitric acid (HNO<sub>3</sub>) and Potassium chlorate (KClO<sub>3</sub>) (Staudenmaier method) or (b) in combination with concentrated HNO<sub>3</sub> and KClO<sub>3</sub> (Hofmann method) or (c) in the absence of HNO<sub>3</sub> but in the presence of Sodium nitrate (NaNO<sub>3</sub>) and Potassium permanganate (KMnO<sub>4</sub>) (Hummers method)<sup>53</sup> | - | ≤0.45 | 0.9 - ≥1 | H<sub>2</sub>SO<sub>4</sub> LD<sub>50</sub> Oral-Rat-2,140 mg/kg. | HNO<sub>3</sub> - KClO<sub>3</sub> LD50 Oral-Rat-1,870 mg/kg. | H<sub>2</sub>SO<sub>4</sub> Extremely corrosive and destructive to tissue. | HNO<sub>3</sub> - KClO<sub>3</sub> LD50 Dermal-Rat-male and female-> > 2,000 mg/kg. | NaNO<sub>3</sub> LD<sub>50</sub> Dermal-Rat- > 5,000 mg/kg. | KMnO<sub>4</sub> Corrosive. |
### S.6 Computational studies on interaction of graphene with curcumin

| Solution and Solid-phase | Few layers (Edge functionalized) | 0.1 | 0.79-1.44 | SO₃ | SO₃ |
|--------------------------|---------------------------------|-----|-----------|-----|-----|
| Dry ball milling graphite in the presence of hydrogen, carbon dioxide, sulfur trioxide, or carbon dioxide/sulfur trioxide mixture\(^{128}\). |  |  | | LC50 Inhalation-Rat-4 h-375 mg/m\(^3\) Extremely corrosive and destructive to tissue.\(^{129}\) | Severe skin irritant.\(^{129}\) |

| Solution Phase | Mono to few layer graphene (less than 10) | 0.06 | 0.20 | LD₅₀ Oral-Rat-female-> 2,000 mg/kg\(^{130}\) | No skin irritation |
|----------------|-----------------------------------|------|-----|---------------------------------|------------------|
| Graphite sonicated with the bio based solvent cyrene for 15 minutes and then centrifuged to obtain graphene oxide\(^{130}\). |  |  | |  | |

![Figure S13](image-url): The optimized structures of curcumin conformers with their energies (a.u) at B97-D/6-31G** level of theory.
Curcumin conformers and curcumin-demethoxyderivatives

Curcumin (keto-enolic form-1)

[Chemical structure image 1]

Curcumin (keto-enolic form -2)

[Chemical structure image 2]

Standard orientation:

Curcumin (keto-enolic form -3)

[Chemical structure image 3]
Curcumin (di-keto form)

DemethoxyCurcumin

Bis-demethoxyCurcumin

Graphene models

C_{160}H_{32}
$\text{C}_{160}\text{H}_{32}$/demethoxycurcumin

$\text{C}_{160}\text{H}_{32}$/bis-demethoxycurcumin
S7. Production of few layer graphene- NR thin film nano-composite

(a) **Preparation of graphene dispersion:** Milled Graphite:Curcumin:Darvan (1:3:0.125) sample was made into a 30 wt. % aqueous dispersion by using probe sonication in distilled water (2 min. at 25 % amplitude).

(b) **Preparation of graphene - NR latex mixture:** The above graphene dispersion (at 0.3, 0.7, 1.5, 3 and 5 phr) was then added to the compounded NR latex using probe sonication technique (3 min. at 20 % amplitude).

(c) **Regulation of compound:** The graphene- NR Latex was stabilized by addition of 1% ammonia and had a solids content of 48 ±3 %. The mixture was stirred slowly to ensure homogeneity and the optimum cure was checked using the following chloroform test.
In a 50 mL beaker 5 mL of the above made NR latex was transferred. Then, 5 mL of chloroform was added to the same and stirred the mixture gently and continuously to obtain a coagulum. This mixture was then kept between two filter papers and pressed. This solid material was broken off gently and judged the nature of cure. All the nanocomposites were made from normal cure NR latex.

Graphene incorporated natural rubber nanocomposite thin films were produced using the following steps;

1) Pre-treatment of glass molds

2) Latex dipping

3) Vulcanization followed by stripping the thin film from mould using silica powder.

Prior to each dipping procedure cleaning of glass molds were done by brushing with detergent water followed by washing with hot water. Later, the molds were dried in hot air oven at 70 °C. For lab scale production, we have used a semi-automatic type dipping machine supplied by PLASTOMEK Private Ltd. India. The thickness of the produced nanocomposite thin film samples can be controlled by varying the dipping speed.

Subsequent to each dipping, the skim and cream on the NR latex surface were removed using a cloth or sponge. The presence of any bubbles was also removed in order to avoid any weak spots on the thin films. The mold fitted on machine is then dipped slowly into the NR latex at a rate of speed of dipping from 1-1.5 cm/sec. After immersing mold up to a required length, the mold was withdrawn slowly and rotated the mold to ensure a uniform flow of the NR Latex. Then, the mold was kept in hot air oven for drying at 70 °C for 2-3 min. After drying and cooling, a second dipping was done and kept for drying again at 70 °C for 2-3 min. For vulcanization, the thin films on the mold are transferred to a hot air oven and heated the product for about 45 min. at a temperature of 80 ± 5 °C.
S8 Characterization of few layer graphene-NR thin film nano-composite

S8.1 TEM analysis

Morphology of the few layer graphene NR thin film nano-composites was analyzed using a JEOL JEM-2010TEM at 200 kV. Samples were prepared by cryo-microtoming at -70 °C.

S8.1.1 TEM analysis of Graphite:Curcumin:Darvan-NR thin film nanocomposite

The TEM images of 1.5 phr Graphite:Curcumin:Darvan containing NR thin film nano-composite are shown as Figure S14. The samples show a network like structure.

![TEM images of 1.5 phr graphene (Graphite:Curcumin:Darvan) reinforced NR latex thin films.](image)

Figure S14 TEM images of 1.5 phr graphene (Graphite:Curcumin:Darvan) reinforced NR latex thin films.

S8.2 Stability of curcumin under the processing condition

1.5 phr few layer graphene -NR thin film nano-composite weighing about 1.11 g was Soxhlet extracted using200 mL of dichloromethane for 2 h. After completion of extraction, a greenish orange color extract was obtained which was then cooled, concentrated using rotavapor to get a greenish orange precipitate.
Characterization of curcumin (obtained after Soxhlet extraction) by thin layer chromatography:

The extract obtained after extraction was subjected to TLC using pre-coated silica gel (Merck 60 F$_{254}$, 20cm×20cm) plates. The curcumin was separated using chloroform: methanol: (9.5:0.5. (Figure S15).

Figure S15: The TLC results of dichloromethane extract obtained after Soxhlet extraction.

* Where A = Soxhlet extract from natural rubber latex (control sample)
   B = Commercial sample of curcumin
   C = Soxhlet extract from control curcumin (thin film having 0.7 phr curcumin and no graphene)
   D = Soxhlet extract from 1.5 phr graphene (Graphene/Curcumin/Darwan)/-NR thin film nanocomposite

A commercial sample of curcumin (B) exhibits three spots (R$_f$ values 0.78, 0.54, 0.50). Similar spots are obtained from control curcumin (C) and 1.5 phr graphene (dry milled Graphene/Curcumin/Darwan)/-NR thin film nano-composite (D). The results confirm that the leached out extract from both control curcumin (C) and 1.5 phr graphene (D) is curcumin. Thus the process does not result in any degradation of curcumin.
Characterization of curcumin (obtained after Soxhlet extraction) by High Performance Liquid Chromatography (HPLC):

The HPLC system consisting of Agilent 1260 series PDA detector was used for this study. Chromatographic separation was achieved using Agilent RP-C18 column (4.6mm×150mm, 5µm). The mobile phase comprised of solvent A: water (1% acetic acid) which was adjusted to pH of 3.0 using 50 % triethanolamine and solvent B: Acetonitrile in the ratio of 50:50 v/v. The isocratic elution was carried out with the flow rate of 1.5 ml/min at ambient temperature. Prior to use, all the samples were filtered through a 0.45 µm membrane filter. The chromatogram was obtained at wavelength of 254 nm.

Preparation of standard and different sample solutions for HPLC:
Stock solutions of standard curcumin, dichloromethane extracts obtained after Soxhlet extraction of natural rubber thin film, curcumin incorporated natural rubber thin film and 1.5phr few layer graphene natural rubber nanocomposite thin film samples were prepared by dissolving 10mg of sample in methanol. The observed peaks (Figure S16) are in agreement with the HPLC chromatograms of standard curcumin as reported by previous researchers131.

Figure S16: HPLC chromatogram of Soxhlet extract obtained from 1.5 phr Graphite:Curcumin:Darvan thin film sample.
**S9 Biocompatibility of graphene-NR latex thin film nanocomposite**

Table S5. Qualitative grading scheme for scoring cytotoxicity based on morphology of cells (Balb/c3T3).

| Grade | Reactivity | Conditions of all culture |
|-------|------------|---------------------------|
| 0     | None       | Discrete intracytoplasmatic granules, no cell lysis, no reduction of cell growth |
|       |            | Not more than 20% of the cells are round, loosely attached and without intracytoplasmic granules, or show changes in morphology; occasional lysed cells are present; only slight growth inhibition observable |
| 1     | Slight     | Not more than 50% of the cells are round, devoid of intracytoplasmic granules |
| 2     | Mild       | Not more than 70% of the cell layers contain rounded cells or are lysed; cell layers not completely destroyed, but more than 50% growth inhibition observable |
| 3     | Moderate   | Nearly complete or complete destruction of the cell layers |
| 4     | Severe     | |

Table S6: Primary index used to predict the skin toxicity on New Zealand white Rabbits.

| Mean Score | Response category |
|------------|-------------------|
| 0 to 0.4   | Negligible        |
| 0.5 to 1.9 | Slight            |
| 2 to 4.9   | Moderate          |
| 5 to 8     | Severe            |
Table S7: Experimental procedure used for performing skin sensitization on guinea pigs.

| Group No. | Animal No. | Sex | Treatment Group | Intradermal Induction Phase (0.1 mL) | Topical induction phase (0.5 mL using a patch)* | Challenge phase # (0.5 mL using a patch)* |
|-----------|------------|-----|----------------|--------------------------------------|-----------------------------------------------|-----------------------------------------------|
|           |            |     |                | Injection I | Injection II | Injection III | 10% SLS | Treatment |                      |
| G1        | 1-5        | F   | Polar solvent control | 1: 1 mixture (v/v) FCA + (saline) | Polar solvent alone | 50% w/v formulation of the vehicle in a 1:1 mixture (v/v) FCA + (saline) | Yes | Polar solvent & Polar extract of Test item |
| G2        | 6-15       | F   | Test item in polar solvent | 1: 1 mixture (v/v) FCA + (saline) | Test item in polar solvent | Polar extract of Test item in a 1:1 mixture (v/v) FCA + (saline) | Yes | Polar extract of Test item & Polar extract of Test item |
| G3        | 16-20      | F   | Non polar solvent control | 1: 1 mixture (v/v) FCA + (sunflower oil) | Non polar solvent alone | 50% w/v formulation of the vehicle in a 1:1 mixture (v/v) FCA + (sunflower oil) | Yes | Non polar solvent & Non polar extract of Test item |
| G4        | 21-30      | F   | Test item in non polar solvent | 1: 1 mixture (v/v) FCA + (sunflower oil) | Test item in non polar solvent | Non polar extract of Test item in a 1:1 mixture (v/v) FCA + (sunflower oil) | Yes | Non polar solvent & Non polar extract of Test item |

F- Female; FCA - Freund’s Complete Adjuvant; SLS - Sodium Lauryl Sulphate;

* Patch area = 8 cm² approximately;
# Gauze soaked in the respective preparation
Intradermal Injection was given on Day 0 at sites A, B and C
Topical application was applied on Day 7
Challenge dose was applied on Day 21
Sites A, B and C are shown below:
Figure S17: 1 – Cranial end; 2 – 0.1 ml intradermal injection sites; 3 – clipped intrascapular region; 4 – Caudal end

Table S8. Positive control experiments performed with α-Hexylcinnamaldehyde for skin sensitization on guinea pigs.

| Concentration of α-Hexylcinnamaldehyde | Vehicle used | Result |
|----------------------------------------|--------------|--------|
| Induction I 0.5% v/v | Induction 2 50% v/v | Challenge 10% v/v | 4:1 v/v acetone: sunflower oil | No of animals +ve +ve in 7/10 animals | Maximum reaction grading Grade 2 - Moderate and confluent erythema |

Table S9. Primary index used to predict for skin sensitization on guinea pigs.

| Patch test reaction | Grading scale |
|---------------------|--------------|
| No visible change   | 0            |
| Discrete or patchy erythema | 1        |
| Moderate and confluent erythema | 2       |
| Intense erythema and/or swelling | 3       |
References

1. V. León, A.M. Rodriguez, P. Prieto, M. Prato, E. Vázquez, Exfoliation of Graphite with Triazine Derivatives under Ball-Milling Conditions: Preparation of Few-Layer Graphene via Selective Noncovalent Interactions, ACS Nano. 8 (2014) 563–571. doi:10.1021/nn405148t.
2. A.C. Ferrari, D.M. Basko, Raman spectroscopy as a versatile tool for studying the properties of graphene, Nat Nano. 8 (2013) 235–246. http://dx.doi.org/10.1038/nnano.2013.46.
3. L. Cancado, A. Reina, J. Kong, M.S. Dresselhaus, Geometrical approach for the study of G’ band in the Raman spectrum of monolayer graphene, bilayer graphene, and bulk graphite, Phys. Rev. B. 77 (2008) 245408. doi:10.1103/PhysRevB.77.245408.
4. V. Leon, M. Quintana, M.A. Herrero, J.L.G. Fierro, A. de la Hoz, M. Prato, E. Vazquez, Few-layer graphenes from ball-milling of graphite with melamine, Chem. Commun. 47 (2011) 10936–10938. doi:10.1039/C1CC14595A.
5. K.R. Paton, E. Varrla, C. Backes, R.J. Smith, U. Khan, A. O’Neill et al., Scalable production of large quantities of defect-free few-layer graphene by shear exfoliation in liquids, Nat Mater. 13 (2014) 624–630. http://dx.doi.org/10.1038/nmat3944.
6. George, G. et al. Thermally conductive thin films derived from defect free graphene-natural rubber latex nanocomposite: Preparation and properties. Carbon 119, (527-534), 2017.
7. Knieke, C. et al. Scalable production of graphene sheets by mechanical delamination. Carbon48, 3196-3204, (2010).
8. Herron, C. R., Coleman, K. S., Edwards, R. S. &Mendis, B. G. Simple and scalable route for the 'bottom-up' synthesis of few-layer graphene platelets and thin films. J. Mater. Chem. 21, 3378- 3383, (2011).
9. Viculis, L. M., Mack, J. J., Mayer, O. M., Hahn, H. T. &Kaner, R. B. Intercalation and exfoliation routes to graphite nanoplatelets. J. Mater. Chem. 15, 974-978, (2005).
10. Liao, K.-H. et al. Aqueous Only Route toward Graphene from Graphite Oxide. ACS Nano 5, 1253-1258, (2011).
11. Feng, H., Cheng, R., Zhao, X., Duan, X. & Li, J. A low-temperature method to produce highly reduced graphene oxide. Nat Commun4, 1539, (2013).
12. Lu, W. et al. High-yield, large-scale production of few-layer graphene flakes within seconds: using chlorosulfonic acid and H2O2 as exfoliating agents. J. Mater. Chem. 22, 8775-8777, (2012).
13. Parviz, D. et al. Dispersions of Non-Covalently Functionalized Graphene with Minimal Stabilizer. ACS Nano 6, 8857-8867, (2012).
14. Eun-Young, C., Won San, C., Young Boo, L. & Yong-Young, N. Production of graphene by exfoliation of graphite in a volatile organic solvent. Nanotechnology 22, 365601, (2011).
15. Green, A. A. &Hersam, M. C. Solution Phase Production of Graphene with Controlled Thickness via Density Differentiation. Nano Lett., (2009).
16. Oh, S. Y., Kim, S. H., Chi, Y. S. & Kang, T. J. Fabrication of oxide-free graphene suspension and transparent thin films using amide solvent and thermal treatment. Appl. Surf. Sci. 258, 8837-8844, (2012).
17. Park, K. H. et al. Exfoliation of Non-Oxidized Graphene Flakes for Scalable Conductive Film. Nano Lett. 12, 2871-2876, (2012).
18. Chabot, V., Kim, B., Sloper, B., Tzoganakis, C. & Yu, A. High yield production and purification of few layer graphene by Gum Arabic assisted physical sonication. *Sci. Rep.* **3**, 1378, (2013).

19. Shang, N. G. *et al.* Controllable selective exfoliation of high-quality graphenenanosheets and nanodots by ionic liquid assisted grinding. *Chem. Commun. (Cambridge, U. K.)* **48**, 1877-1879, (2012).

20. (a) Behabtu, N. *et al.* Spontaneous high-concentration dispersions and liquid crystals of graphene. *Nat Nano* **5**, 406-411, (2010).(b) Lu, W. *et al.* High-yield, large-scale production of few-layer graphene flakes within seconds: using chlorosulfonic acid and H2O2 as exfoliating agents. *J. Mater. Chem.* **22**, 8775-8777, (2012).

21. Yi, M., Shen, Z., Zhang, X. & Ma, S. Vessel diameter and liquid height dependent sonoication-assisted production of few-layer graphene. *J. Mater. Sci.* **47**, 8234-8244, (2012).

22. Lotya, M. *et al.* Liquid Phase Production of Graphene by Exfoliation of Graphite in Surfactant/Water Solutions. *J. Am. Chem. Soc.* **131**, 3611-3620, (2009).

23. Sanna, R. *et al.* Synthesis and characterization of graphene-containing thermoresponsive nanocomposite hydrogels of poly(N-vinylcaprolactam) prepared by frontal polymerization. *Journal of Polymer Science Part A: Polymer Chemistry* **50**, 4110-4118, (2012).

24. Nuvoli, D. *et al.* High concentration few-layer graphene sheets obtained by liquid phase exfoliation of graphite in ionic liquid. *J. Mater. Chem.* **21**, 3428-3431, (2011).

25. Shahil, K. M. F. & Balandin, A. A. Graphene–Multilayer Graphene Nanocomposites as Highly Efficient Thermal Interface Materials. *Nano Lett.* **12**, 861-867, (2012).

26. Hamilton, C. E., Lomeda, J. R., Sun, Z., Tour, J. M. & Barron, A. R. High-Yield Organic Dispersions of Unfunctionalized Graphene. *Nano Lett.* **9**, 3460-3462, (2009).

27. An, X., Simmons, T., Shah, R., Wolfe, C., Lewis, K.M., Washington, M., et al. *Nano Lett.* **10**, 4295–4301, (2010).

28. Scognamillo, S. *et al.* Synthesis and characterization of nanocomposites of thermoplastic polyurethane with both graphene and graphene nanoribbon fillers. *Polymer* **53**, 4019-4024, (2012).

29. Shih, C.-J. *et al.* Bi- and trilayer graphene solutions. *Nat Nano* **6**, 439-445, (2011)

30. Zhao, W. *et al.* Preparation of graphene by exfoliation of graphite using wet ball milling. *J. Mater. Chem.* **20**, 5817-5819, (2010).

31. Min, Y., Zhigang, S., Xiaojing, Z. & Shulin, M. Achieving concentrated graphene dispersions in water/acetone mixtures by the strategy of tailoring Hansen solubility parameters. *J. Phys. D: Appl. Phys.* **46**, 025301, (2013).

32. Kang, M. S., Kim, K. T., Lee, J. U. & Jo, W. H. Direct exfoliation of graphite using a non-ionic polymer surfactant for fabrication of transparent and conductive graphene films. *Journal of Materials Chemistry C* **1**, 1870-1875, (2013).

33. O’Neill, A., Khan, U., Nirmalraj, P. N., Boland, J. & Coleman, J. N. Graphene Dispersion and Exfoliation in Low Boiling Point Solvents. *Journal of Physical Chemistry C* **115**, 5422-5428, (2011).

34. Catheline, A. *et al.* Graphene solutions. *Chem. Commun. (Cambridge, U. K.)* **47**, 5470-5472, (2011).
35. Vadukumpully, S., Paul, J. & Valiyaveettil, S. Cationic surfactant mediated exfoliation of graphite into graphene flakes. *Carbon* **47**, 3288-3294, (2009).
36. Englert, J. M. *et al.* Soluble Graphene: Generation of Aqueous Graphene Solutions Aided by a Perylenebisimide-Based Bolaamphiphile. *Adv. Mater. (Weinheim, Ger.)* **21**, 4265-4269, (2009).
37. Smith, R. J., Lotya, M. & Coleman, J. N. The importance of repulsive potential barriers for the dispersion of graphene using surfactants. *New Journal of Physics* **12**, (2010).
38. Alzari, V. *et al.* In situ production of high filler content graphene-based polymer nanocomposites by reactive processing. *J. Mater. Chem.* **21**, 16544-16549, (2011).
39. Nuvoli, D. *et al.* The production of concentrated dispersions of few-layer graphene by the direct exfoliation of graphite in organosilanes. *Nanoscale Research Letters* **7**, 674, (2012).
40. Nuvoli, D. *et al.* The production of concentrated dispersions of few-layer graphene by the direct exfoliation of graphite in organosilanes. *Nanoscale Research Letters* **7**, 674, (2012).
41. Fu, W., Kiggans, J., Overbury, S. H., Schwartz, V. & Liang, C. Low-temperature exfoliation of multilayer-graphene material from FeCl3 and CH3NO2 co-intercalated graphite compound. *Chem. Commun. (Cambridge, U. K.)* **47**, 5265-5267, (2011).
42. (a) Torrisi, F. *et al.* Inkjet-Printed Graphene Electronics. *ACS Nano* **6**, 2992-3006, (2012).  
(b) Khan, U. *et al.* Size selection of dispersed, exfoliated graphene flakes by controlled centrifugation. *Carbon* **50**, 470-475, (2012).  
(c) Alzari, V. *et al.* Graphene-containing thermoresponsive nanocomposite hydrogels of poly(N-isopropylacrylamide) prepared by frontal polymerization. *J. Mater. Chem.* **21**, 8727-8733, (2011).  
(d) Khan, U. *et al.* Solvent-Exfoliated Graphene at Extremely High Concentration. *Langmuir* **27**, 9077-9082, (2011).  
(e)  
43. Buzaglo, M. *et al.* Critical parameters in exfoliating graphite into graphene. *Phys. Chem. Chem. Phys.* **15**, 4428-4435, (2013).
44. Seo, J.-W. T., Green, A. A., Antaris, A. L. & Hersam, M. C. High-Concentration Aqueous Dispersions of Graphene Using Nonionic, Biocompatible Block Copolymers. *The Journal of Physical Chemistry Letters* **2**, 1004-1008, (2011).
45. Wang, X. Q. *et al.* Direct exfoliation of natural graphite into micrometre size few layers graphene sheets using ionic liquids. *Chem. Commun. (Cambridge, U. K.)* **46**, 4487-4489, (2010).
46. Lotya, M., King, P. J., Khan, U., De, S. & Coleman, J. N. High-Concentration, Surfactant- Stabilized Graphene Dispersions. *ACS Nano* **4**, 3155-3162, (2010).
47. Wang, H., Robinson, J. T., Li, X. & Dai, H. Solvothermal Reduction of Chemically Exfoliated Graphene Sheets. *J. Am. Chem. Soc.* **131**, 9910-9911, (2009).
48. Marago, O. M. *et al.* Brownian Motion of Graphene. *ACS Nano* **4**, 7515-7523, (2010).
49. Li, X. L., Wang, X. R., Zhang, L., Lee, S. W. & Dai, H. J. Chemically derived, ultrasmoothgraphenenanoribbon semiconductors. *Science* **319**, 1229-1232, (2008).
50. Safavi, A., Tohidi, M., Mahyari, F. A. & Shahbaazi, H. One-pot synthesis of large scale graphenenananosheets from graphite-liquid crystal composite via thermal treatment. *J. Mater. Chem.* **22**, 3825-3831, (2012).
51. Wang, J., Manga, K. K., Bao, Q. & Loh, K. P. High-Yield Synthesis of Few-Layer Graphene Flakes through Electrochemical Expansion of Graphite in Propylene Carbonate Electrolyte. *J. Am. Chem. Soc.* **133**, 8888-8891, (2011).
52. Valles, C. et al. Solutions of Negatively Charged Graphene Sheets and Ribbons. J. Am. Chem. Soc. 130, 15802-+, (2008).
53. Poh, H.L., Sanek, F., Ambrosi, A., Zhao, G., Sofer, Z., & Pumera, M. Graphenes prepared by Staudenmaier, Hofmann and Hummers methods with consequent thermal exfoliation exhibit very different electrochemical properties. Nanoscale 4, 3515-3522, (2012).
54. Curcumin; MSDS Product No. C7727; Available from Sigma-Aldrich
http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN&language=en&productNumber=C7727&brand=SIGMA&PageToGoToURL=http%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fproduct%2Fsigma%2Fc7727%3Flang%3Den.
(Accessed on 07.04.2017)
55. Kohli, K., Ali, J., Ansari, M. J., Raheman, Z. Curcumin: A natural antiinflammatory agent. Indian J Pharmacol 2005;37:141-7
56. Sittisomwong N., Leelasangaluk V., Chivapat S., Wangmad A., Ragsaman P., Chuntarachaya C., Acute and subchronic toxicity of turmeric. Bull. Dept. Med. Sci. 1990. 32(3):101-111.
57. Tetrahydrocurcumin; http://www.chemblink.com/MSDS/MSDSFiles/36062-04-1_Clear%20Synth.pdf (Accessed on 02.05.2017).
58. Quercetin; MSDS Product No. Q4951; Available from Sigma-Aldrich
http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN&language=en&productNumber=Q4951&brand=SIGMA&PageToGoToURL=http%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fproduct%2Fsigma%2Fq4951%3Flang%3Den.
(Accessed on 27.04.2017)
59. 1-Methyl-2-pyrrolidinone; MSDS Product No.M6762; Available from Sigma Aldrich http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN&language=en&productNumber=M6762&brand=SIGMA&PageToGoToURL=%252Fcatalog%252Fproduct%252Fsigma%252Fm6762%253Flang%253Den (Accessed on 26.05.2017).
60. Polyvinyl alcohol; MSDS Product No. 341584; Available from Sigma Aldrich http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN&language=en&productNumber=341584&brand=ALDRICH&PageToGoToURL=%252Fcatalog%252Fproduct%252Faldrich%252F341584%253Flang%253Den (Accessed on 31.05.2017).
61. Melamine; MSDS Product No. M2659; Available from Sigma-Aldrich.
http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN&language=en&productNumber=M2659&brand=ALDRICH&PageToGoToURL=http%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fsearch%3Fterm%3DMelamine%26interface%3DProduct%252FSearch%26N%3D0%2B%26mode%252520match%252520partial%252520max%252520%26lang%253D%26region%3DIN%26focus%3Dproduct%3D0%2520220003048%2520219853286%2520219853147.(Accessed on 27.04.2017).
62. Anthony Kai-ching Hau, Tze Hoi Kwan, and Philip Kam-tao Li. Melamine Toxicity and the Kidney. J Am SocNephrol 20: 245–250, 2009.
63. Sodium dodecyl sulfate; MSDS Product No.L3771; Available from Sigma-Aldrich.
http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN&language=en&productNumber=L3771&brand=SIGMA&PageToGoToURL=http%3A%2F%2F
77. https://toxnet.nlm.nih.gov/cgi-bin/sis/search/a?dbs+hsdb:@term+@DOCNO+909 (Accessed on 02.05.2017).
78. Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989., p. 334.
79. Isopropanol; MSDS Product No.W292907; Available from Sigma-Aldrich. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN&language=en&productNumber=W292907&brand=ALDRICH&PageToGoToURL=http%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fsearch%3Fterm%3Disopropanol%26interface%3DAll%26N%3D0%26mode%3Dmatch%2520partial%26lang%3Den%26region%3DIN%26focus%3DProduct (Accessed on 27.04.2017).
80. Organization for Economic Cooperation and Development; Screening Information Data Set for Sodium Isopropanol (67-63-0) p.21 (January 1998). Available from, as of September 22, 2011: http://www.inchem.org/pages/sids.html
81. N-Methyl-2-pyrrolidone; MSDS Product No.W292907; Available from Sigma-Aldrich.http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN&language=en&productNumber=328634&brand=SIAL&PageToGoToURL=http%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fsearch%3Fterm%3DN-Methyl-2-pyrrolidone%26interface%3DAll%26N%3D0%26mode%3Dmatch%2520partial%26lang%3Den%26region%3DIN%26focus%3DProduct (Accessed on 27.04.2017).
82. Malley LA et al; Drug ChemToxicol 24 (4): 315-38 (2001).
83. Gum arabic; MSDS Product No.G9752 ; Available from Sigma-Aldrich. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN&language=en&productNumber=G9752&brand=SIGMA&PageToGoToURL=http%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fsearch%3Fterm%3DGum%2Barabic%2Bfrom%2BBacacia%2Btree%26interface%3DProduct%2520Name%26N%3D0%26mode%3Dmatch%2520partial%26lang%3Den%26region%3DIN%26focus%3DProduct (Accessed on 27.04.2017).
84. Mamleevank, Bakhtizinagz; Gig TrOkhrZdorovyaRabNeftNeftekhim Prom-sti 9: 110-13 (1976).
85. Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989., p. 334.
86. Cyclohexane; MSDS Product No.P6001; Available from Sigma-Aldrich. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN&language=en&productNumber=227048&brand=SIAL&PageToGoToURL=http%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fsearch%3Fterm%3Dcyclohexane%26interface%3DAI%26N%3D0%26mode%3Dmatch%2520partial%26lang%3Den%26region%3DIN%26focus%3DProduct (Accessed on 27.04.2017).
87. Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2017; CCIS Volume 172, edition expires May, 2017. Hall AH &Rumack BH (Eds): TAMES(R) Information System Micromedex, Inc., Englewood, CO, 2017; CCIS Volume 172, edition expires May, 2017
88. Sodium dodecylbenzenesulfonate; MSDS Product No. 289957; Available from Sigma-Aldrich. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN&language=en&productNumber=289957&brand=ALDRICH&PageToGoToURL=http%3A%2F
n-Vinylcaprolactam; P MSDS Product No.M-218; Scientific polymer Products, Inc. http://scientificpolymer.com/wp-content/uploads/2013/12/M-218-GHS.pdf (Accessed on 02.05.2017).

n-Vinylcaprolactam; MSDS Product No.415464; Available from Sigma-Aldrich. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN&language=en&productNumber=415464&brand=ALDRICH&PageToGoURL=http%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fsearch%3Fterm%3DSodium%2Bdodecylbenzenesulfonate%26interface%3DProduct%2520Name%26N%3D0%2B%26mode%3Dmode%2520matchpartialmax%26lang%3Den%26region%3DIN%26focus%3DProductN%3D0%2520220003048%2520219853286%2520219853147 (Accessed on 27.04.2017).

http://pubchem.ncbi.nlm.nih.gov/compound/1-Hexyl-3-methylimidazolium_hexafluorophosphate#section=Top (Accessed on 02.05.2017).

Sodium chlorate; MSDS Product No. SLS4057; Available from ScienceLab.com. http://www.sciencelab.com/msds.php?msdsId=9927592 (Accessed on 02.05.2017).

Organization for Economic Cooperation and Development; Screening Information Data Set for 1,2-Dichlorobenzene, 95-50-1 p.9 (November 6-9, 2001). Available from, as of January 31, 2008: http://www.chem.unep.ch/irptc/sids/OECDSIDS/sidspub.html.

Organization for Economic Cooperation and Development; Screening Information Data Set for 1,2-Dichlorobenzene, 95-50-1 p.106 (November 6-9, 2001). Available from, as of February 4, 2008: http://www.chem.unep.ch/irptc/sids/OECDSIDS/sidspub.html.

Organization for Economic Cooperation and Development; Screening Information Data Set for 1,2-Dichlorobenzene, 95-50-1 p.179 (November 6-9, 2001). Available from, as of February 7, 2008: http://www.chem.unep.ch/irptc/sids/OECDSIDS/sidspub.html.

Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. 2920.

European Chemicals Bureau; IUCLID Dataset, phenyl isocyanate (103-71-9) (2000 CD-ROM edition). Available from, as of March 16, 2012: http://esis.jrc.ec.europa.eu.

N,N-dimethylformamide; http://nj.gov/health/eho/rtkweb/documents/fs/1027.pdf

N,N-dimethylformamide; MSDS Product No.227056; Available from Sigma-Aldrich. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN&language=en&productNumber=227056&brand=SIAL&PageToGoURL=http%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fsearch%3Fterm%3DDimethylformamide%26interface%3DProduct%2520Name%26N%3D0%2B%26mode%3Dmode%2520matchpartialmax%26lang%3Den%26region%3DIN%26focus%3DProductN%3D0%2520220003048%2520219853286%2520219853147 (Accessed on 27.04.2017).

European Chemicals Bureau; IUCLID Dataset, ACETONE (67-64-1). Available from, as of January 22, 2007: http://esis.jrc.ec.europa.eu/

European Chemicals Bureau; IUCLID Dataset, ACETONE (CAS No 67-64-1). Available from, as of January 22, 2007: http://esis.jrc.ec.europa.eu/

Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983., p. 150.

Hexadecyltrimethylammoniumbromide; MSDS Product No.H9151; Available from Sigma Aldrich.
104. Sodium dodecyl sulfate; MSDS Product No. 71727; Available from Sigma Aldrich.
http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN&language=en&productNumber=71727&brand=SIAL&PageToGoToURL=%2Fcatalog%2Fproduct%2Fsial%2F71727%253Flang%253Den (Accessed on 26.05.2017).

105. Dodecylbenzenesulfonic acid; MSDS Product No. 71727; Available from ScienceLab.com. http://www.scientelab.com/msds.php?msdsId=9923881 (Accessed on 26.05.2017).

106. Hexadecyltrimethylammonium bromide; MSDS Product No. H5882; Available from Sigma Aldrich.
http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN&language=en&productNumber=H5882&brand=SIAL&PageToGoToURL=%2Fcatalog%2Fsigma%2Fh5882%253Flang%253Den (Accessed on 26.05.2017).

107. Myristyltrimethylammonium bromide; MSDS Product No. T4762; Available from Sigma Aldrich.http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN&language=en&productNumber=T4762&brand=SIAL&PageToGoToURL=%2Fcatalog%2Fproduct%2Fsial%2Ft4762%253Flang%253Den (Accessed on 26.05.2017).

108. Sodium deoxycholate; MSDS Product No. D6750; Available from Sigma Aldrich.http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN&language=en&productNumber=D6750&brand=SIAL&PageToGoToURL=%2Fcatalog%2Fproduct%2Fsial%2Fd6750%253Flang%253Den (Accessed on 30.05.2017).

109. IGEPAL CO-890; MSDS Product No. 238678; Available from Sigma Aldrich.http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN&language=en&productNumber=238678&brand=ALDRICH&PageToGoToURL=%2Fcatalog%2Fproduct%2Fsial%2F238678%253Flang%253Den (Accessed on 30.05.2017).

110. Tween 20; MSDS Product No. P1379; Available from Sigma Aldrich.http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN&language=en&productNumber=P1379&brand=SIAL&PageToGoToURL=%2Fcatalog%2Fproduct%2Fsial%2Fp1379%253Flang%253Den (Accessed on 30.05.2017).

111. Tween 80; MSDS Product No. P1754; Available from Sigma Aldrich.http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN&language=en&productNumber=P1754&brand=SIAL&PageToGoToURL=%2Fcatalog%2Fproduct%2Fsial%2Fp1754%253Flang%253Den (Accessed on 30.05.2017).

112. Tetra(ethylene glycol) diacrylate; MSDS Product No. 398802; Available from Sigma Aldrich.http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN&language=en&productNumber=398802&brand=SIAL&PageToGoToURL=%2Fcatalog%2Fproduct%2Fsial%2F398802%253Flang%253Den (Accessed on 30.05.2017).
113. Triethoxyphenylsilane; MSDS Product No. 175609; Available from Sigma Aldrich. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN &language=en&productNumber=175609&brand=ALDRICH&PageToGoToURL=%252Fcatalog%252Fproduct%252Faldrich%252F175609%253Flang%253Den(Accessed on 26.05.2017).

114. 3-Glycidyloxypropyl)trimethoxysilane; MSDS Product No. 440167; Available from Sigma Aldrich. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN &language=en&productNumber=440167&brand=ALDRICH&PageToGoToURL=%252Fcatalog%252Fproduct%252Faldrich%252F440167%253Flang%253Den(Accessed on 26.05.2017).

115. Iron(III) chloride; MSDS Product No. F7134; Available from Sigma Aldrich. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN &language=en&productNumber=F7134&brand=SIAL&PageToGoToURL=%252Fcatalog%252Fproduct%252Fsial%252FF7134%253Flang%253Den(Accessed on 26.05.2017).

116. Nitromethane; MSDS Product No. 108170; Available from Sigma Aldrich. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN &language=en&productNumber=108170&brand=SIAL&PageToGoToURL=%252Fcatalog%252Fproduct%252Fsial%252F108170%253Flang%253Den(Accessed on 26.05.2017).

117. 1-butyl-3-methyl-imidazoliumbis(trifluoromethanesulfonyl)imide; MSDS Product No. 77896; Available from Sigma Aldrich. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN &language=en&productNumber=77896&brand=ALDRICH&PageToGoToURL=%252Fcatalog%252Fproduct%252Faldrich%252F77896%253Flang%253Den(Accessed on 30.05.2017).

118. 1,2-dichloroethane; MSDS Product No. 284505; Available from Sigma Aldrich. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN &language=en&productNumber=284505&brand=SIAL&PageToGoToURL=%252Fcatalog%252Fproduct%252Fsial%252F284505%253Flang%253Den(Accessed on 31.05.2017).

119. Propylene carbonate; MSDS Product No. 310328; Available from Sigma Aldrich. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN &language=en&productNumber=310328&brand=SIAL&PageToGoToURL=%252Fcatalog%252Fproduct%252Fsial%252F310328%253Flang%253Den(Accessed on 31.05.2017).

120. Sulfuric acid; MSDS Product No. 435589; Available from Sigma Aldrich. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN &language=en&productNumber=435589&brand=SIAL&PageToGoToURL=%252Fcatalog%252Fproduct%252Fsial%252F435589%253Flang%253Den(Accessed on 31.05.2017).

121. Potassium chlorate; MSDS Product No. 255572; Available from Sigma Aldrich. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN
122. Sodium nitrate; MSDS Product No. S5506; Available from Sigma Aldrich. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN &language=en&productNumber=S5506&brand=SIGALD&PageToGoToURL=%252Fcatalog%252Fsearch%252Fterm%25252fS5506%253Den%2526interface%25252fAll%252526N%2526mode%25252fpartialmax%252526lang%25252fen%2526region%25252fIN%252526focus%25252f253Dproduct(Accessed on 31.05.2017).

123. Potassium permanganate; MSDS Product No. 60458; Available from Sigma Aldrich. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN &language=en&productNumber=60458&brand=SIGALD&PageToGoToURL=%252Fcatalog%252Fsearch%252Fterm%25252f60458%253Den%2526interface%25252fAll%252526N%2526mode%25252fpartialmax%252526lang%25252fen%2526region%25252fIN%252526focus%25252f253Dproduct(Accessed on 31.05.2017).

124. Larson, L.L., Kenaga, E.E., Morgan, R.W. Commercial and Experimental Organic Insecticides. 1985 Revision. College Park, MD: Entomological Society of America, 1985., p. 25.

125. Ruth JH; Am Ind Hyg Assoc J 47: A-142-51 (1986)

126. Chloroform solution; MSDS Product No. 487163; Available from Sigma-Aldrich. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN &language=en&productNumber=487163&brand=SIGALD&PageToGoToURL=http%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fsearch%2Fterm%2f487163%2f3DChloroform%2f3DAll%2f26N%2f26mode%2f26lang%2f3Den%2f26region%2f3D%2fproduct(Accessed on 27.04.2017).

127. (a) Jeon, I-Y., et al. Large-Scale Production of Edge-Selectively Functionalized Graphene Nanoplatelets via Ball Milling and Their Use as Metal-Free Electrocatalysts for Oxygen Reduction Reaction. J. Am. Chem. Soc. 135, 1386–1393, (2013). (b) Jeon, I-Y., et al. Scalable Production of Edge-Functionalized Graphene Nanoplatelets via Mechanochemical Ball-Milling. Adv. Funct. Mater. 135, 6861-6975, (2015). (c) Jeon, I-Y., et al. Edge-carboxylated graphene nanosheets via ball milling. PNAS 109, 5588–5593, (2012)

128. Sulfur trioxide; MSDS Product No. 227692; Available from Sigma-Aldrich. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN &language=en&productNumber=227692&brand=ALDRICH&PageToGoToURL=%252Fcatalog%252Fproduct%252f227692%252f3DAll%2526N%2526mode%252fpartialmax%2526lang%252f3Den%2526region%252f3D%252Dproduct(Accessed on 03.06.2017).

129. H, J, Salavagione., J, Sherwood., M, Debruyn., V, L, Budarin., G, J, Ellis.,J, H, Clark.& P, S, Shuttleworth. Identification of high performance solvents for the sustainable processing of graphene. Green Chemistry 19, 2550-2560, (2017).

130. Cyrene; MSDS Product No. 807796; Available from Sigma-Aldrich. http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=IN &language=en&productNumber=807796&brand=SIGALD&PageToGoToURL=http%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fsearch%2Fterm%2f807796%2f3DAll%26N%26mode%26lang%26region%26focus%263Dproduct(Accessed on 03.06.2017).
131. R. Jangle, B. Thorat, Reversed-phase high-performance liquid chromatography method for analysis of curcuminoids and curcuminoid-loaded liposome formulation, Indian J. Pharm. Sci. 75 (2013) 60–66.