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Figure 1.15  ROS mediated antibacterial activity of zinc oxide nanoparticles.

Figure 1.16  Biofilm cascade inhibition provide opportunities for preparing more effective therapeutics.

Figure 3.1  Characterization of graphene/zinc oxide nanocomposite: (a, b) TEM image and particle size analysis of GZNC, (c) UV visible spectra of graphene, zinc oxide and GZNC, (d) FTIR spectra of GZNC.

Figure 3.2  a) X ray diffraction pattern and (b) TG curve of GZNC.

Figure 3.3  Inhibitory effect of sub-MIC concentrations of GZNC on: (a) sucrose dependent adherence, (b) biofilm formation, (c) viability (XTT assay), (d) Glucan formation.

Figure 3.4  The growth curves of treated and untreated SM 497, SM 06 and SM 34 cells over 24 hours.

Figure 3.5  (a) Congo red agar method: control plate showing more black crystalline colonies as compared to treated (b) Congo red binding assay: showing considerable decrease in amount of exopolysaccharide.

Figure 3.6  Effect of GZNC on biofilm architecture: SEM image of S. mutans biofilm in (a) absence and (b) presence of GZNC, CLSM image of S. mutans: (c, f) Control biofilm, (d, g) 32.2 µg ml⁻¹ GZNC treated biofilm, (e, f) 62.5µg ml⁻¹ GZNC treated biofilm.

Figure 3.7  Formation of ROS in presence of GZNC.

Figure 3.8  In vitro cytotoxicity assay (MTT) on HEK-293 cell line in presence of GZNC.

Figure 3.9  CLSM image of internalization of GZNC in HEK-293 cell line (a, f) control, (b, g) 100µg ml⁻¹, (c, h) 200µg ml⁻¹, (d, i) 300µg ml⁻¹, (e, j) 400µg ml⁻¹.

Figure 3.10  (a) Photograph of non-coated and (c) GZNC coated acrylic teeth; SEM images of surface of teeth (b) control and (d) coated; Region from where SEM analysis for biofilm formation was done (e) control and (g) treated; Magnified view of selected regions: (f) In control showing well defined biofilm architecture and (h) almost negligible biofilm on treated; (i) Quantification of the biofilm biomass; Photograph of crystal violet stained (j, k) Control tooth and (l, m) treated tooth.

Figure 3.11  Schematic representation of mechanism of nucleation of...
zinc oxide nanoparticle on surface of functionalized graphene sheets.

**Figure 3.12** Schematic representation of proposed mechanism of antibiofilm activity of GZNC.

**Figure 4.1** Characterization of CaF$_2$-NPs: (a) Transmission electron microscopy image of CaF$_2$-NPs, (b) Particle size ~ 15-25 nm, (c) UV visible spectrum of CaF$_2$-NPs, (d) Scanning electron microscopy image, (e) FTIR spectrum, and (e) XRD pattern of CaF$_2$-NPs.

**Figure 4.2** Inhibitory effect of sub-MIC concentration of CaF$_2$-NPs (a) Biofilm formation (b) EPS production.

**Figure 4.3** Growth curve of treated and untreated *S. mutans* with sub-MIC concentrations of CaF$_2$-NPs.

**Figure 4.4** Inhibitory effect of sub-MIC concentration of CaF$_2$-NPs (a) Adherence assay (b) Preformed biofilm reduction.

**Figure 4.5** Inhibitory effect of CaF$_2$-NPs on synthesis of water soluble polysaccharide and water insoluble polysaccharide (Glucans).

**Figure 4.6** Effect on sub-MIC levels of CaF$_2$-NPs on glycolytic pH-drop (the values enclosed in box corresponds to the initial rate of pH drop).

**Figure 4.7** Expression profile of various genes of *S. mutans* in response to treatment of sub-MIC concentration of CaF$_2$-NPs.

**Figure 4.8** Effect of CaF$_2$-NPs on biofilm architecture: Confocal laser scanning micrographs of control biofilm (a, b, c, d), micrographs of treated biofilm 4mg/ml (e, f, g, h), 2mg/ml (i, j, k, l), 1 mg/ml (m, n, o, p).

**Figure 4.9** Transmission electron microscopy images of *Streptococcus mutans*: (a) control (b) treated with sub-MIC concentration of CaF$_2$-NPs.

**Figure 4.10** *In vitro* cytotoxicity assay (MTT) on HEK-293 cell line.

**Figure 4.11** Effect of sub-MIC level of CaF$_2$-NPs on dental caries development in rats.
Figure 4.12 SEM analysis of rats’ teeth to evaluate the effect of CaF₂-NPs on caries development and extent of demineralization in treated (lower panel) and untreated groups (upper panel): (a) Untreated rat tooth showing caries (magnification 200X), (b, c) magnified view of marked region showing biofilm of *S. mutans* on untreated tooth (magnification 10X), (a’) CaF₂-NPs treated tooth (magnification 200X), (b’, c’) magnified view of marked region of a treated tooth (magnification 10X).

Figure 5.1 Characterization of GO-Ag: (a) TEM image of GO (b) TEM image of GO-Ag (c) Particle size distribution of silver nanoparticles (d) UV-vis spectra of GO and GO-Ag.

Figure 5.2 XRD pattern of (a) GO and (b) GO-Ag.

Figure 5.3 EDX spectra of (a) GO and (b) GO-Ag.

Figure 5.4 MBC of GO and GO-Ag against *S. mutans* and *E. cloacae*.

Figure 5.5 (a) Effect of sub inhibitory concentrations of GO and GO-Ag on *S. mutans* biofilm formation, where T1 is 47 µg ml⁻¹ and T2 is 24 µg ml⁻¹ (b) Effect of sub inhibitory concentrations of GO and GO-Ag on *E. cloacae* biofilm formation, where T1 is 24 µg ml⁻¹ and T2 is 12 µg ml⁻¹ (c) Effect of GO and GO-Ag on growth curve pattern of *S. mutans* (d) Effect of GO and GO-Ag on growth curve pattern of *E. cloacae*.

Figure 5.6 (a) Effect of GO-Ag on cell membrane integrity of *S. mutans* and *E. cloacae* (b) Amount of reactive oxygen species generation by GO-Ag in *S. mutans* and *E. cloacae*.

Figure 5.7 Scanning electron microscopy images of biofilm treated with sub inhibitory concentration of GO-Ag: (a, b) inhibition of *S. mutans* biofilm, (c, e) inhibition of *E. cloacae* biofilm, (c) magnified view of *S. mutans* in control biofilm, (d) magnified view of *S. mutans* in treated biofilm showing no change in cell wall integrity, (g) magnified view of *E. cloacae* in control biofilm, (h) magnified view of *E. cloacae* in treated biofilm, red arrow depicting loss of intracellular component.

Figure 5.8 Confocal laser scanning microscopy images stained with SYTO9 (green, live) and PI (red, dead): (a, c) control biofilm of *S. mutans*, (b, d) treated biofilms of *S. mutans*, (e, g) control biofilms of *E. cloacae*, (f, h) treated biofilms of *E. cloacae*.

Figure 5.9 Gene expression profile of specific genes involved in the formation of *S. mutans* biofilm.
**Figure 5.10** Effect of GO and GO-Ag on viability of HEK-293 cell line.

**Figure 5.11** Schematic representation of green synthesis of GO-Ag: (a) Graphene oxide was prepared by Hummers method, (b) plant extract was used to reduce GO to RGO, (c) silver nanoparticle was reduced and stabilized onto the surface of GO with help of plant extract.