

# Toxicity of graphene towards the bacteria and mammalian cells

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Graphene is a two-dimensional material consisting of carbon atoms arranged in a honeycomb-like hexagonal lattice. There are some conflicting reports regarding the antibacterial and biocompatibility of different forms of graphene. Some studies suggests the bactericidal effects of graphene flakes, due to the penetration of sharp graphene edges into the lipid membrane, and of toxicity of graphene is due to its charge transfer ability.<sup>1,2</sup> To address this issue, we analyzed the antibacterial effect of graphene based on the orientation of flakes. Vertical Graphene was grown on SiO<sub>2</sub> and Au substrates where monolayer CVD graphene was used as a control to test the toxicity towards bacterial and mammalian cells.

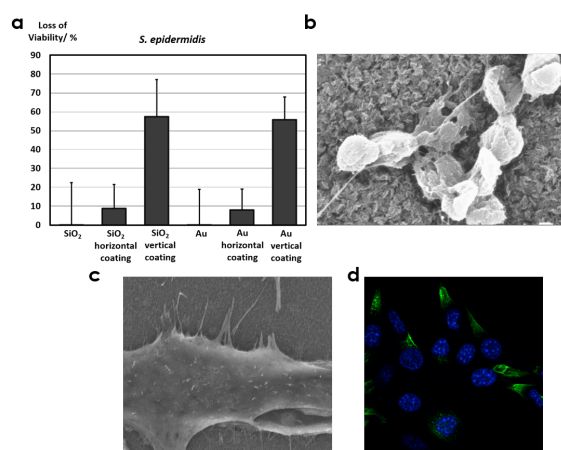
Interestingly, vertically coated graphene significantly reduced the viability of bacteria while the effect of horizontally coated graphene was neutral. None of the graphene samples showed any toxicity towards the mammalian cells. To see the interaction of vertically grown graphene spikes with bacterial and mammalian cells, we performed SEM analysis. SEM images clearly shows the disruption of bacterial cell membrane by the penetration of vertically aligned graphene spikes unlike for the mammalian cells. To confirm the toxic/nontoxic effect of graphene, live/dead staining was carried out and analyzed using fluorescence microscope. We observed many dead bacterial cells with vertically aligned graphene but not in horizontally aligned graphene while no

dead mammalian cells were observed in both forms. These finding suggests that the antibacterial effect of graphene is associated with flakes orientation and harmless to mammalian cells.

## References

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## Figures



**Figure 1:** a) Loss of viability of *S. epidermidis* on vertical graphene, b) SEM image of morphologically disturbed bacterial cell on vertical graphene, c) SEM image of mouse fibroblast cell on vertical graphene and d) Live/dead viability image of mouse fibroblast cells on vertical graphene.

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