Viral Deactivation by Carbon Nanostructures and their Functionalized Analogs

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Introduction

- The recent spread of Coronavirus disease (COVID-19) across the world has ushered in an increased demand for antiviral nanomaterials which can be embedded as components of personal protective equipment.
- Carbon nanotubes (CNTs), graphene oxide (GO) and reduced graphene oxide have previously been used in filtration and have removed virus particles, this present study will show how functionalization of these nanocarbons enhance the ability of nanocarbons to deactivate viruses.

The objective of this research was to study the antiviral properties of carbon nanostructures namely CNTs, GO and rGO and to investigate the effect of functionalization (phenol and silver) on their antiviral activities.

Materials and Methods

❖MS2 Bacteriophage Growth

The virus was grown with E.coli and then via centrifugation, the viral supernatant was separated and filtered.

❖Nanomaterial Preparation

The nanocarbons were functionalized via chemical treatment, filtered, washed and vacuum dried.

❖ Experimental Setup

The nanocarbons were mixed with the viral cultures at room temperature for an hour and the samples were plated on LB Agar plates using the DAL technique to observe the growth of viral plaques.

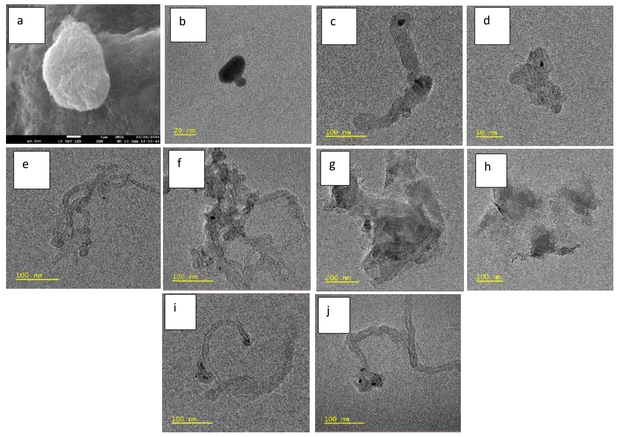
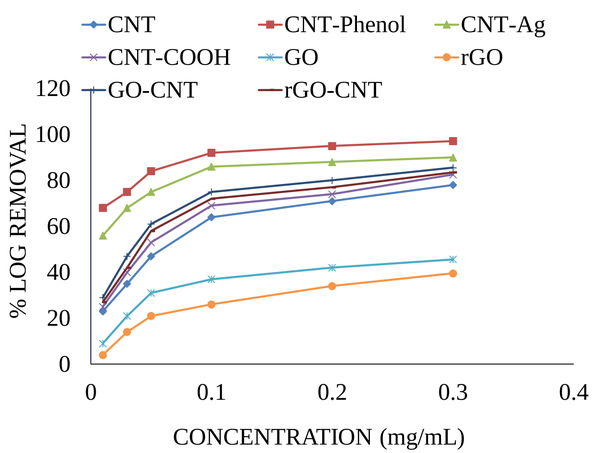


Figure 1a. SEM image of agglomerated viral particles entangled by CNTs; TEM image of b. virus; c. virus in contact with CNTs; d. virus in contact with CNT-phenol; e. virus in contact with CNT-Ag; f. virus in contact with CNT-COOH; g. virus in contact with GO; h. virus in contact with rGO; i. virus in contact with GO-CNT; j. virus in contact with rGO-CNT.



Results

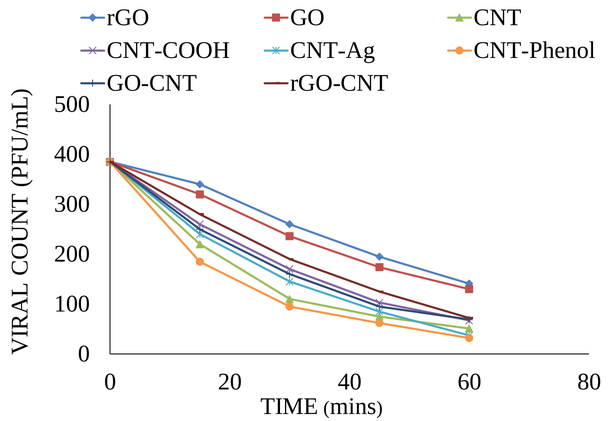
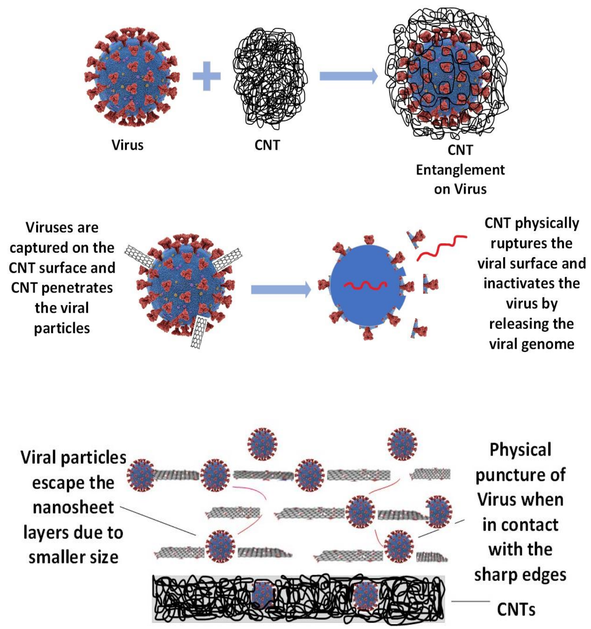


Figure 2b. Viral Deactivation Kinetics

Table 1. Kinetic Parameters related to Viral Deactivation

Nanomaterials	T_{50} (min)	T_{80} (min)	LD_{50} (µg/mL)	Specific Growth Rate (SGR) of MS2 Bacteriphage (min^{-1})	Initial Deactivation Rate (IRD) (min^{-1})
rGO	43	69.3	105	-0.018	-4.22
GO	46.9	74.4	55	-0.017	-4.37
CNT	25.5	46.8	14	-0.034	-5.41
CNT-COOH	30.9	52.7	10	-0.029	-5.32
rGO-CNT	33.4	55.6	8	-0.028	-5.21
GO-CNT	29.8	51.9	6	-0.029	-5.24
CNT-Ag	27.5	47.9	0.1	-0.039	-5.71
CNT-Phenol	22.6	43.5	0.01	-0.041	-5.51

Proposed Mechanism



Conclusion

- CNTs by itself were highly effective but an enhancement in activity was observed for all functionalized analogs of CNT.
- The activities of GO and rGO were greatly enhanced by factors of 650 and 950% respectively at a concentration of 0.05mg/mL when combined with the CNTs.
- Conjugation of CNTs with silver and phenol at 0.05mg/mL also increased the overall viral deactivation efficiency by factors of 200% and 270% respectively.

Acknowledgements

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Reference: Gupta, I., Azizighannad, S., Farinas, E. T., & Mitra, S. (2021). Antiviral properties of select carbon nanostructures and their functionalized analogs. *Materials Today Communications*, *29*, 102743.