

Soft conductive silicone composites based on carbon nanotubes modified with ferrocenyl-containing polysiloxanes

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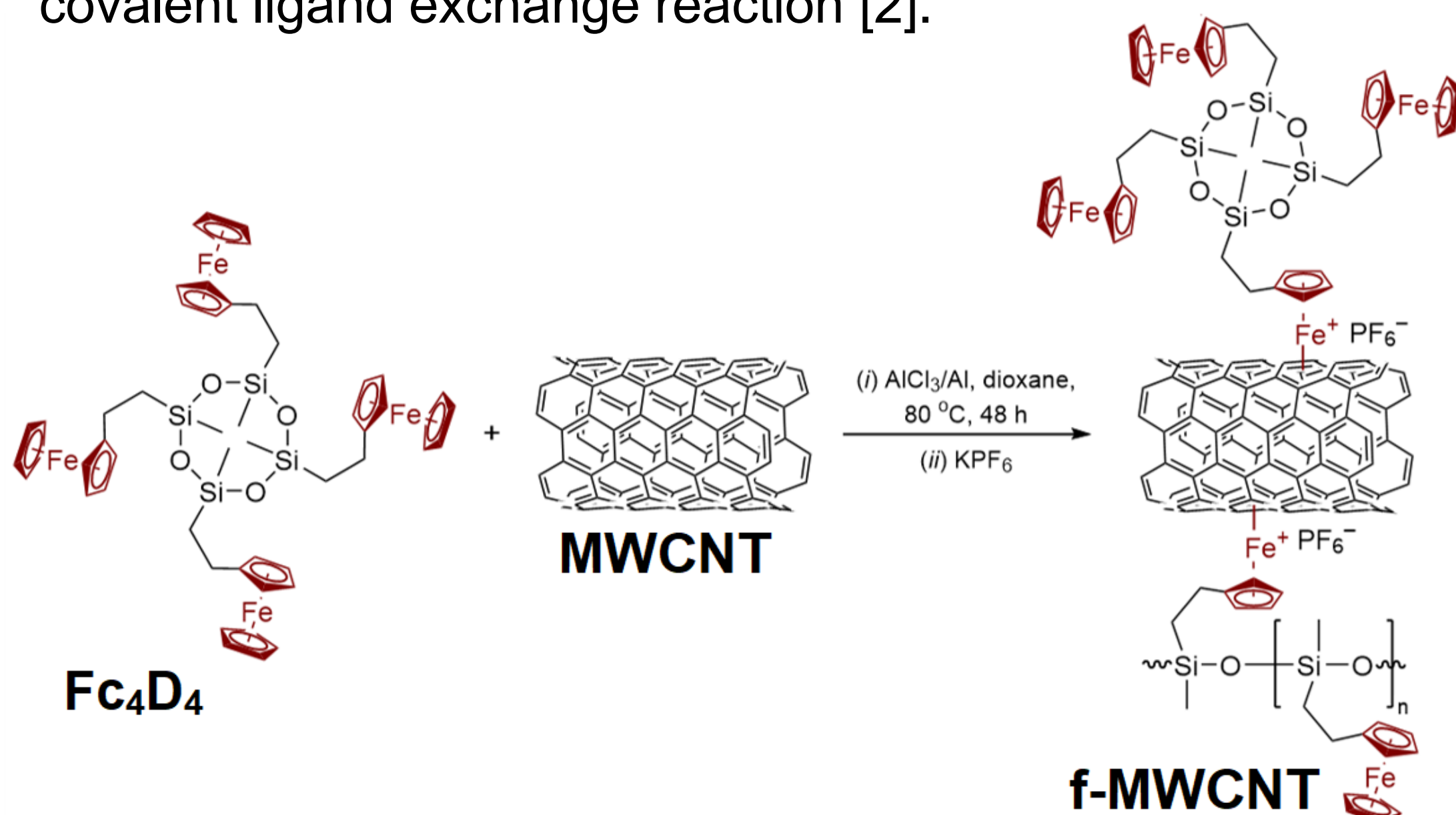
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INTRODUCTION & AIM

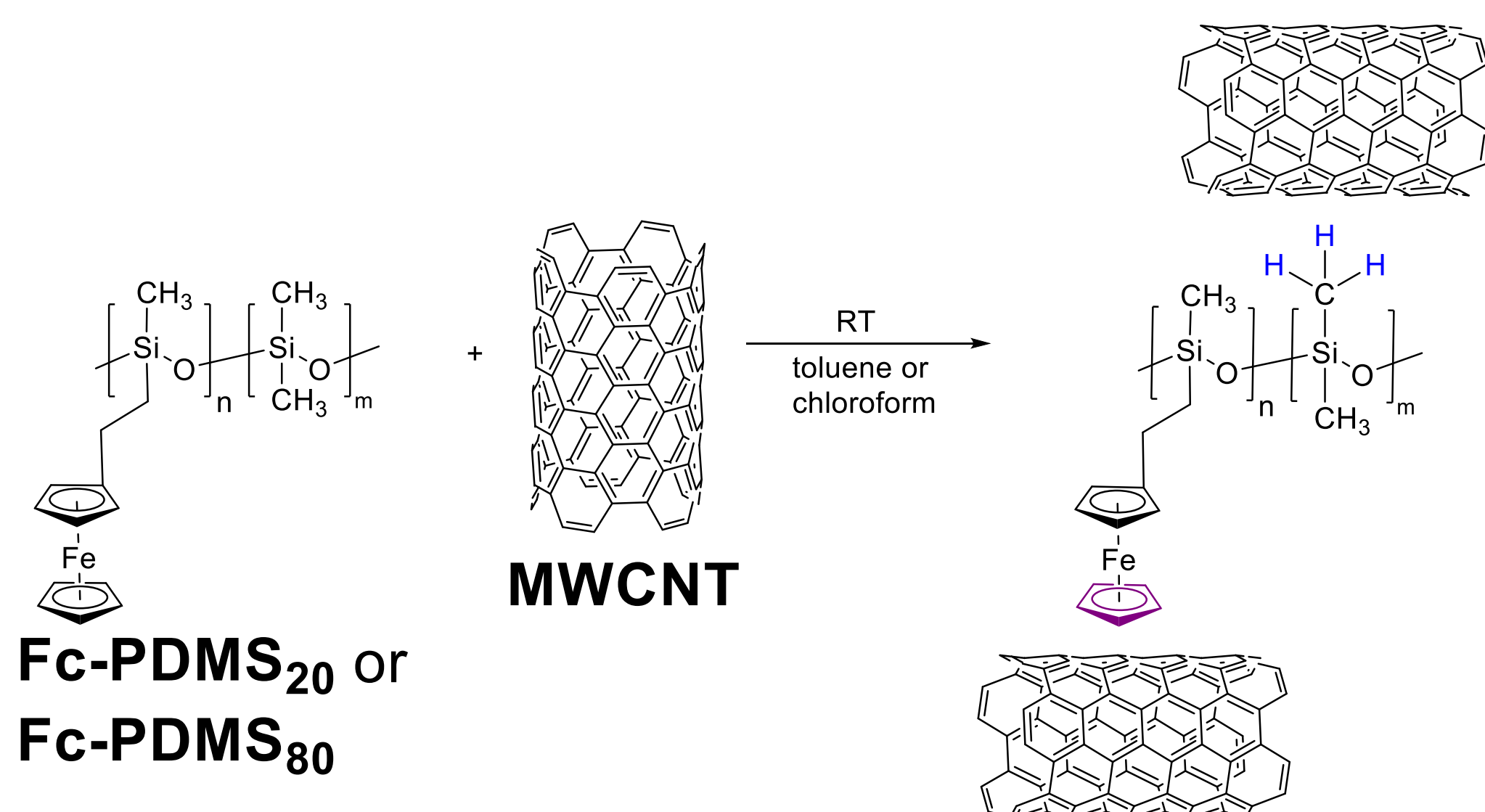
Soft, flexible and conductive silicone composites reinforced with carbon nanotubes (CNT) are widely used in different fields [1]. Usually, non-modified carbon fillers demonstrate poor distribution in polymer matrices resulting in deterioration of composite properties. Better distribution of CNT in polymer matrix are usually achieved *via* functionalization of the CNT surface with polymers. Among polymers, ferrocenyl-containing polysiloxanes can be used due to the unique properties of polysiloxanes and their ability to interact with CNT surface as well as the presence of redox-active moieties allowing the use the resulting material for sensing technologies, energy storage devices, etc. [2]. Thus, we used two different approaches to modify CNT with ferrocenyl-containing polysiloxanes.

METHOD

Ferrocenyl-containing (poly)siloxanes bearing 100 mol.% of ferrocenyl groups were grafted to the CNT surface *via* covalent ligand exchange reaction [2].



Simultaneously CNT were modified by ferrocenyl-containing polysiloxanes containing 20 and 80 mol.% of ferrocenyl groups (Fc-PDMS₂₀ and Fc-PDMS₈₀) [3].



The successful modification of MWCNT was confirmed by Raman and X-Ray photoelectron spectroscopy [2,3].

RESULTS & DISCUSSION

Covalent modification of MWCNT for the preparation of soft conductive silicone composites

Specific resistivity (R_{spec}) at different frequencies (10^0 – 10^6 Hz) was measured for pure PDMS Sylgard™ 184 and its composites with f-MWCNT (100 mol.% of ferrocenyl groups) at 5 and 10 wt.%. Incorporation of 5 wt.% of f-MWCNT allowed to obtain composite with R_{spec} $2 \cdot 10^{12}$ Ohm·cm compared to $7 \cdot 10^{13}$ of pure PDMS. Higher concentration (10 wt.%) of modified MWCNT resulted in R_{spec} $8 \cdot 10^8$ Ohm·cm in the obtained composite. Good distribution of MWCNT was demonstrated by scanning electron microscopy in composites with modified MWCNT [2].

Non-covalent modification of MWCNT for composites

We also prepared silicone composites containing 5 wt.% MWCNT modified with ferrocenyl-containing polysiloxanes (Fc-PDMS₂₀ and Fc-PDMS₈₀). R_{spec} of composites with MWCNT/Fc-PDMS₂₀ and MWCNT/Fc-PDMS₈₀ was equal to $1 \cdot 10^7$ and $5 \cdot 10^8$ Ohm·cm, respectively [3].



Photographs of the soft conductive silicone composites

CONCLUSION

Thus, modified with ferrocenyl-containing polysiloxanes MWCNT can be used for conductive silicone composites preparation, which are in demand in the fields of soft electronics and biomedicine.

Additionally, modified MWCNT can be used as a pre-prepared solution for a subsequent application on a template or electrode for their potential use as components of ion-separation systems or selective adsorption of organic molecules [3].

ACKNOWLEDGEMENT

Study was supported by the Russian Science Foundation (project 24-13-00038).

REFERENCES

- Barshutina, M.N., Volkov, V.S., Arsenin, A.V., Nasibulin, A.G., Barshutin, S.N., Tkachev, A.G., Silicone composites with CNT/graphene hybrid fillers: A review. *Materials*, **2021**, *14*(9), p.2418.
- Golovenko, E.A., Pankin, D.V., Deriabina, K.V., Kirichenko, S.O., Perevyazko, I., Koroleva, A.V., Islamova, R.M., Modified with ferrocenyl-containing oligo- and polysiloxanes multi-walled carbon nanotubes for soft conductive silicone composites. *Mater. Today Commun.*, **2024**, *41*, p.110429.
- Golovenko, E.A., Pankin, D.V., Kirichenko, S.O., Islamova, R.M., Influence of ferrocenyl groups content in polysiloxanes on carbon nanotubes performance. *J. Mater. Sci.: Mater. Electron.*, **2025**, *36*(24), p.1536.