Electrically Conductive Flexible UHMWPE Composites based on Perfluoropolyethers-functionalized Carbon-based Fillers

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Abstract

Flexible conductive **UHMWPE** composite materials filled with carbon black (**CB**) or nanotubes (**CNTs**) and perfluoropolyether (**PFPEs**) chains were used in the production of **flexible electrodes**. PFPE bonding facilitate the formation of nanofillers-rich conductive pathways and improves composites' electrical conductivity up to 5 order of magnitude more[1]. The decrease of the overpotential for hydrogen oxidation peaks in samples containing PFPE functionalized CNTs and hydrogen production (approximately −1.0 V vs. SHE) suggests that these samples could find application **in fuel cell technology** as well as in **hydrogen storage devices**[2].

Methods and Materials

Three different CNTs were investigated:

- **CNT_0** without PFPE functionalization
- **CNT_{F1}** with a ratio 2:1 CNT:PFPE
- **CNT_{F2}** with a ratio 1:1 CNT:PFPE

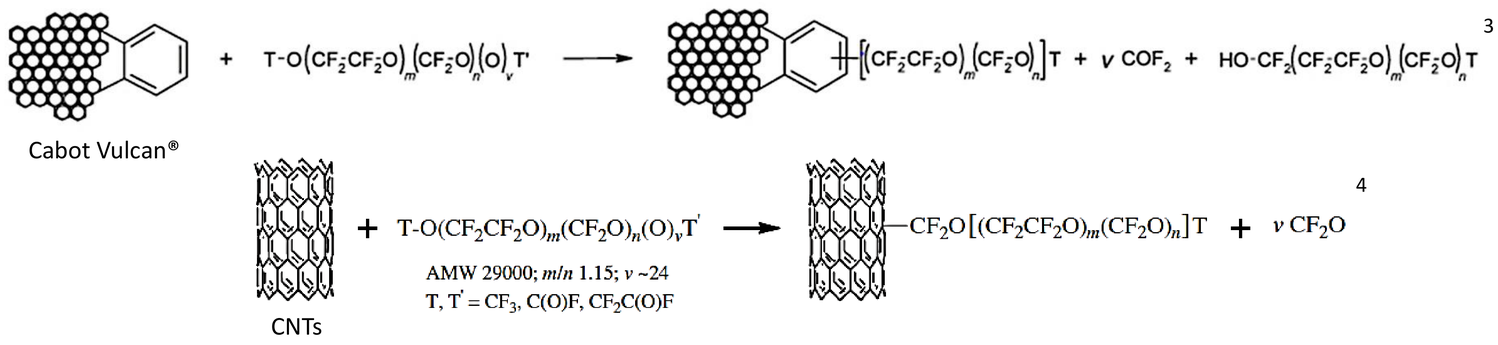
Two CB (Cabot Vulcan®) were tested:

- **CB_0** without PFPE functionalization
- **CB_{F1}** with a ratio 1,67:1 CB:PFPE

Powdered UHMWPE was mixed with different **filler loadings** (0.5, 1.0, 3.0, 5.0 wt.%).

Functionalization

Perfluoroalkylation of carbon-based materials starting from PFPE peroxide.



Electrical Resistivity

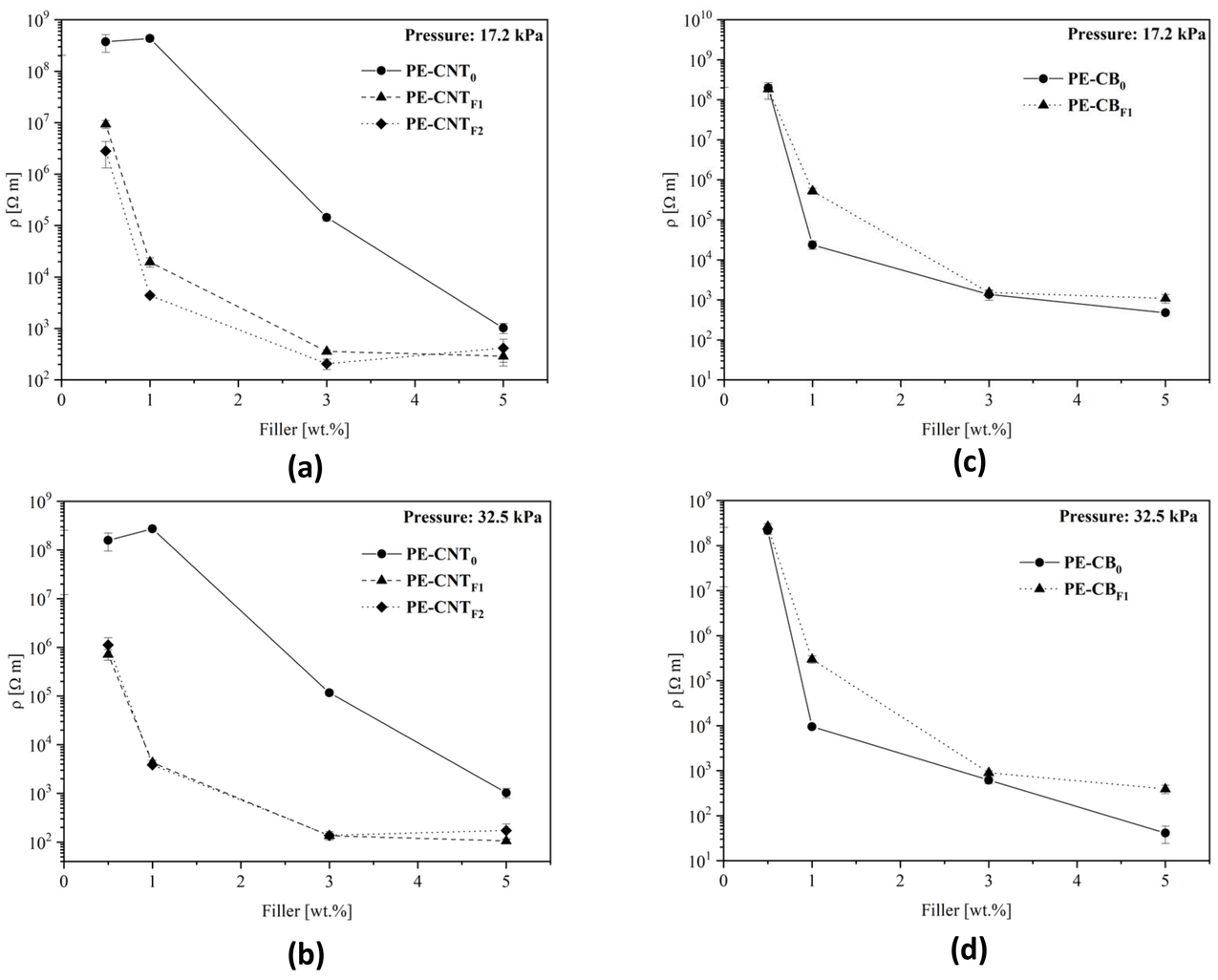


Fig 1. *Electrical resistivity vs filler content (wt%) at different pressure.*

Electrical resistivity of UHMWPE-based nanocomposites as a function of the filler contents at two different applied pressures: 17.2 kPa (a,c) and 32.5 kPa (b,d). **Pristine CNTs and CB present higher resistivity than the ones functionalized with PFPE**. Thanks to these properties, a fuel cell containing these hybrid materials could easily overcome the actual technological limits, especially related to the high intrinsic resistivity of CNTs.

Bend and Torsional tests

CNT_{F2}-5wt% sample is completely curved, reaching a bending radius (r) of 2 mm as shown in ***Fig 2***.

Fig 2. *Bending test and flexibility.*

Hydrogen evolution

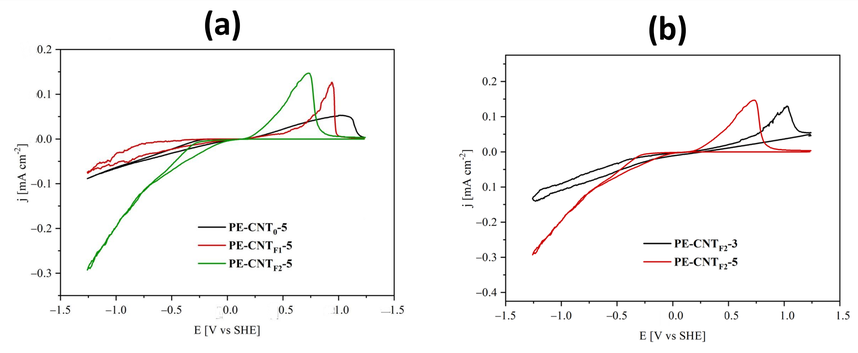


Fig 3. *a) Cyclic voltammograms of PE-CNT_0, PE-CNT_{F1} and PE-CNT_{F2} with 5wt.% filler loading*
b) Cyclic voltammograms of PE-CNT_{F2} with 5wt.% and 3wt.% of filler loading

CNTs-based thin films possess the characteristic peak of hydrogen oxidation unlike CBs, which seems unable to store hydrogen electrochemically. **Hydrogen oxidation current peaks are more pronounced** with both **increasing PFPE content** in the filler and **increasing filler load** at the same PFPE content.

Conclusions

Flexible conductive composites based on ultra-high molecular weight polyethylene (**UHMWPE**) filled with multi-walled carbon nanotubes (CNTs) modified by perfluoropolyethers (**PFPEs**) were synthetized. The dispersion of PFPE functionalized CNTs **enhanced the conductivity and the flexibility of the polymeric matrix**. These preliminary results open up new promising perspectives regarding the utilization of PFPE-modified CNTs as **flexible electrodes** for **fuel cells** and **hydrogen storage devices**.

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References

1 - Dintcheva, N. T. et al. 95, 29–39 (**2016**).
2 - Sansotera, M. et al. 15, 1–17 (**2022**).
3 - Sansotera, M. et al. 21, 4498–4504 (**2009**).
4 - Talaeemashhadi, S. et al. 59, 150-159 (**2013**).

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