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Novel High Barrier and Piezoelectric Nanocomposites based on Fluorinated Polymer

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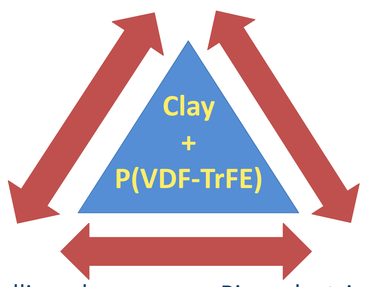
Objectives and Challenges

Thermo-mechanical treatment (*e.g. annealing*)



Crystalline phases α, polar-β

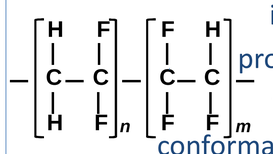
Piezoelectric and Gas-Barrier properties

Development of a high pressure composite **storage vessel** with **self-sensing piezoelectric liner**

Development of a high-barrier AND piezoelectric poly(vinylidene fluoride-trifluorethylene) P(VDF-TrFE) based material

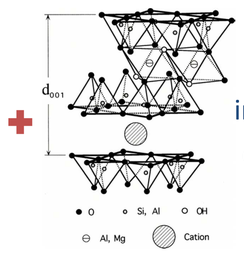
Materials and Microstructural Analysis

P(VDF-TrFE)



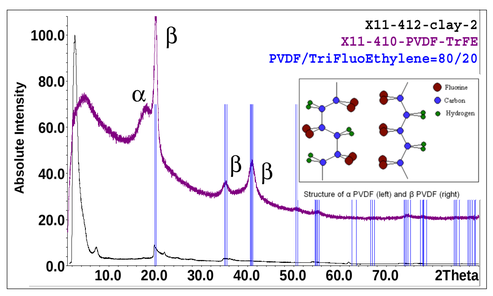
Semicrystalline polymer with interesting electric properties originated from its molecular conformation and the chain packing in the crystalline regions

Clay – Cloisite 15A



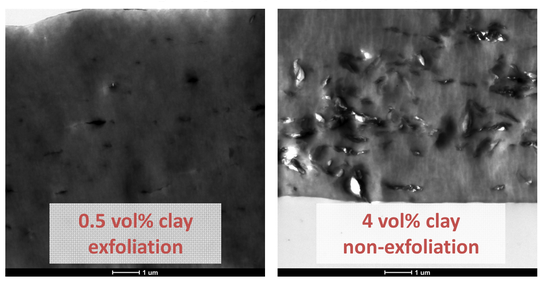
Organically modified mineral commonly added in nanocomposites because of its layered structure and dispersibility in suitable media

XRD patterns of pure P(VDF-TrFE) and pure CLAY

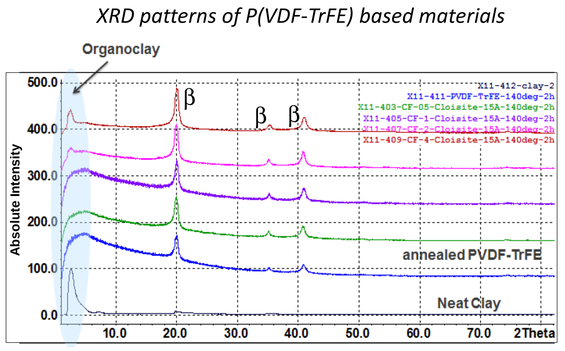


Presence of α and polar β crystalline phases in P(VDF-TrFE) The phase β is responsible for the piezoelectric properties of polymer

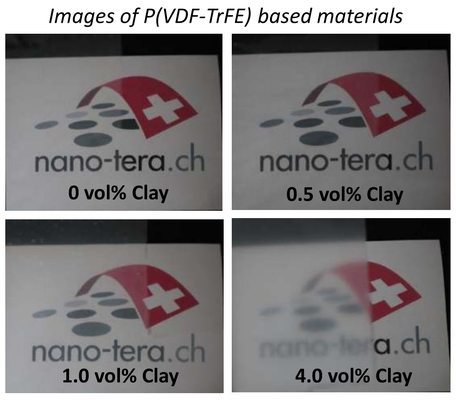
TEM images of P(VDF-TrFE)/clay composites



XRD patterns of P(VDF-TrFE) based materials

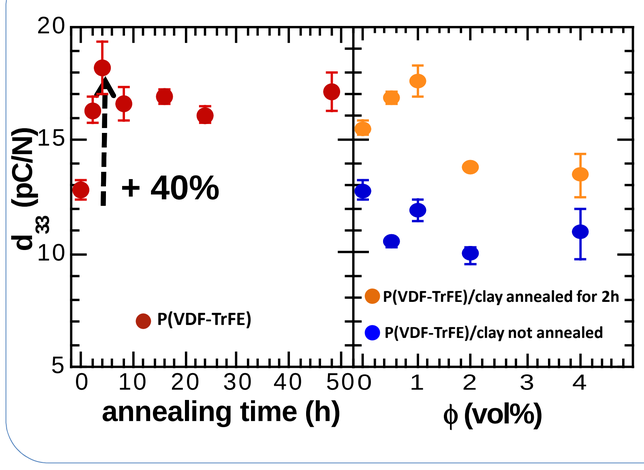


Images of P(VDF-TrFE) based materials



Predominance of β crystalline phase upon annealing of P(VDF-TrFE) based materials obtained by solvent cast. The addition of more than 1 vol% of clay leads to non-exfoliated fillers and loss of transparency

Piezoelectric properties



The higher crystallinity found for annealed P(VDF-TrFE) based films contributed to the increase of 40% in the d_{33} coefficient. The presence of clay led to the lowering of d_{33}.

Acknowledgements

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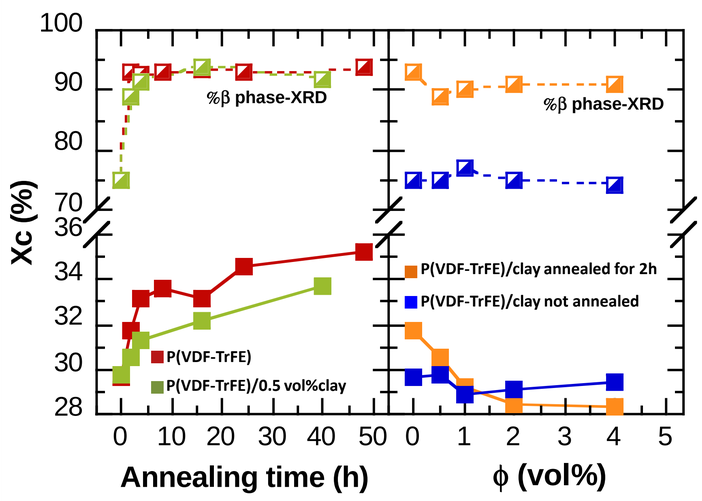
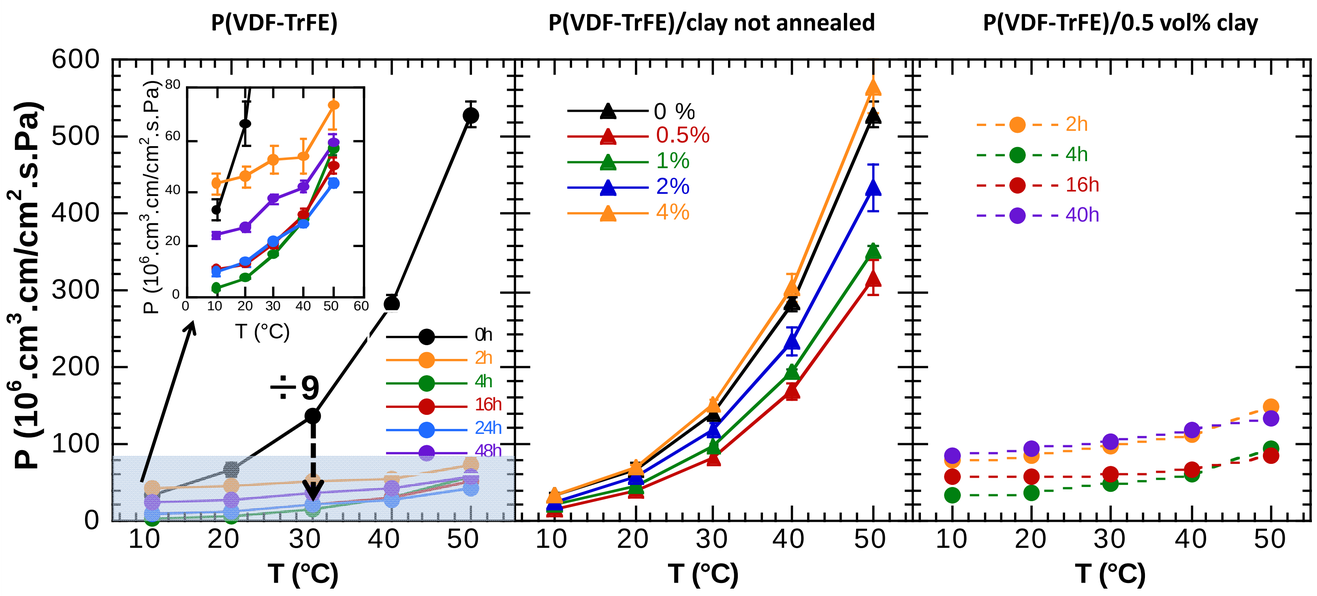
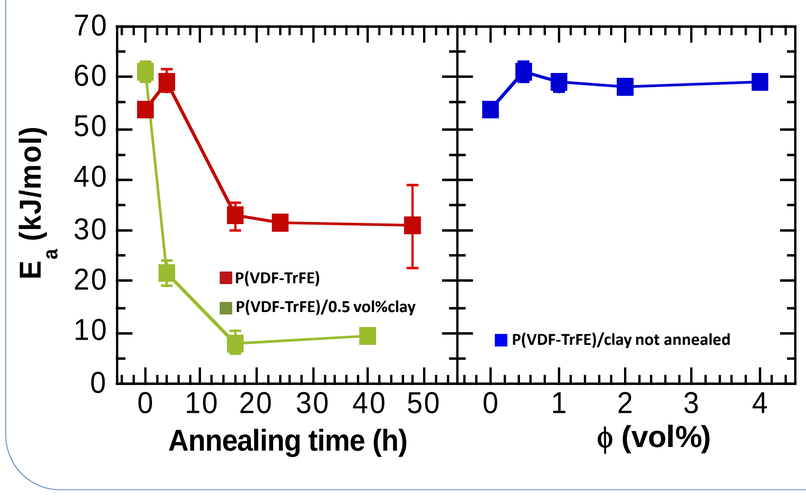
Crystalline structure and Gas-Barrier properties



Calorimetry analyses (DSC) showed that annealing at 130° C increased the crystallinity (Xc) of P(VDF-TrFE) and its nanocomposites. The proportion of polar β phase increased up to 94% during annealing. The addition of clay limited the enhancement of Xc in the composites.



Annealing showed a remarkable effect on the O_2 permeability (P) of P(VDF-TrFE) with values at least 9 times lower than not annealed samples. The addition of clay enhanced moderately the gas barrier properties of P(VDF-TrFE).



Activation Energy (Ea) for O_2 transport is considerably reduced upon annealing and unchanged with addition of clay.

Conclusions

- **Annealing PVDF-TrFE at 130° C for 4h increases d_{33} by 40% and decreases oxygen permeability by a factor of 9.**
- **The increased β-phase proportion upon annealing is responsible for the combined increase of piezoelectric and gas-barrier properties.**
- **Addition of clay leads to exfoliated nanocomposites (0.5 vol%) or microcomposites (> 2 vol%) with no change in crystallinity and no improvement in piezoelectric properties.**

References

- S. Dalle Vacche, F. Oliveira, Y. Leterrier, V. Michaud, D. Damjanovic, J.-A.E. Månson, Journal of Materials Science 11, 47, 4763 - 4774 (2012).
- E. Bellet-Amalric and J. F. Legrand, The European Physical Journal B. 3, 225 - 236 (1998).
- A. J. Lovinger, Science, 220, 1115 -1118 (1983).