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Tobias Lange, Thibault Charpentier, Frédéric Gobeaux, Sophie Charton, Fabienne Testard, Antoine Thill

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Tobias Lange[1, 2], Thibault Charpentier[2], Frédéric Gobeaux[2], Sophie Charton[1], Fabienne Testard[2] and Antoine Thill[2]

1. CEA, DEN, DMRC, SA2I, BP17171, 30207 Bagnols sur Cèze, France,
2. CEA, DRF, IRAMIS, NIMBE, UMR 3685, CNRS, Université Paris-Saclay, 91191 Gif sur Yvette, France.

Abstract:
The natural Imogolite clay ((HO)3Al2O3SiOH) with nano-tubular structure of 2-3 nm diameter is a promising candidate for polymer reinforcement, water treatment and other applications.[1] However, its hydrophilic external gibbsite like surface limits its use in hydrophobic environment. Among the different possible grafting functions for the outer surface, the phosphonic acid moiety is the most used. It shows strong reactivity with imogolite [1]. If the resulting product can be dispersed in a hydrophobic environment, the impact of the reaction on the tubular structure was never demonstrated and experimental evidence of grafted dispersed imogolite tubes with a brush-like layer on their exterior is still missing [2].
By combining different experimental techniques (SAXS, IR, MAS NMR, SEM and TEM) we systematically characterized the reaction product of imogolite and (decyl)phosphonic acid [3]. The product shows properties which were previously ascribed to grafted tubes [2], but no evidence for grafting is found. Instead, we observed the formation of a lamellar phase at the expense of the tubular structure, which forms a composite material with the remaining imogolite tubes. This newly formed material has unusual interfacial properties able to stabilize water droplets in toluene. The exhibited reactivity can be explained by the surface chemistry of the imogolite. Beyond the particular case of imogolite reactivity, the approach described here opens an interesting synthetic strategy to form hierarchical materials from nanoparticles dispersion.

References

[1] P. Yuan, A. Thill, and F. Bergaya, Nanosized tubular clay minerals: Halloysite and Imogolite. Elsevier(2016).
[2] P. Picot, O. Taché, F. Malloggi, T. Coradin, A. Thill, Faraday Discuss, 191, 391-406 (2016).
[3] T. Lange, T. Charpentier, F. Gobeaux, S. Charton, F. Testard, A. Thill, Langmuir, 35, 4068–4076 (2019).