Nanotubular alumino-silicates and analogues (imogolites): formation and biological interactions.

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Imogolite is probably the best known nanotubular alumino-silicate structure occurring naturally. Imogolite, and more commonly their precursors, can be encountered in Andosols, where they play a determining role in carbon cycling.

These compounds are attractive model structures for investigating the effects of High Aspect Ratio Nanotubes (HARN) since they are hydrophilic, environmentally relevant, and can be readily obtained in various lengths without catalysts which may cause biased toxicity results. Several recipes to synthesize imogolite by a simple sol-gel process have been published over the past 3 decades; however they all have in common to have very poor yields and slow kinetics. More recently, an alumino-germanate isostructural to natural imogolite (hereafter called Ge-imogolite), has been successfully synthesized in large quantities by our group, thereby opening the road to a full range of physico-chemical, (eco)toxicological and environmental transfer studies; the formation mechanisms have still not been entirely elucidated; nevertheless we observed ca. 5 nm roof-tile shaped nucleation products (precursors), which assemble/transform into rings; further growth is likely to proceed by a tip-to-tip mechanism.

Unfortunately, although yield issues have been addressed, no real progress on was made on the kinetics and better tube length control (i.e. roughly monomodal length distribution) still remains difficult to achieve. On top of this, tube length measurement itself still bears challenges since commercial PCS has proven to be ill-suited for these high aspect ratio structures, and TEM lacks statistical significance.

Here we present novel reaction protocols to cut the synthesis time from one solid week to several hours without comprising on quality. Also, we developed a simple and "routine-compatible" procedure to measure a meaningful particle size distribution.

We also show that the acute effect of these materials on several model biological targets (human skin cells, rhizosphere bacteria) is somewhat counterintuitive to the common concept of the fiber effect (i.e. longer = worse), but long term damage still needs further evaluation