Preparation of one-dimensional hybrid nanostructures based on Te and Au

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One-dimensional Te nanostructures (Te1D) in the shape of whiskers, wires and helices were prepared by a facile one-pot synthesis in the presence of aqueous Pluronic® F68 solution at low temperatures (< 100 ºC) under Te:H3PO2 molar ratio of 1:5 ([Te] = . Te nanowhiskers, nanohelices and nanowires were synthesized at 40 ºC, 60 ºC and 90 ºC. A detailed inspection of the tip end of nanowhiskers unveiled both amorphous and crystalline phases shaped into wave-like structure. The middle portion of Te nanowhiskers displayed a structure rich in plane defects such as dislocation and stacking faults. When the reaction temperature is set to 60 ºC, crystalline Te nanohelices is achieved. The Te nanohelices had diameter in the range of 9-20 nm and lengths below 1 μm.

We took advantage of the low temperature and all aqueous synthesis of phenol-formaldehyde resin to design functional core-shell Te1D nanostructures with preserved shape. Formaldehyde and resorcinol undergo a polymerization reaction to form resin in the presence of ammonia (as a catalyst), with polymer Pluronic® F68 as stabilizer. TEM images shown in Figure 1B reveal that the product are essentially 1D core–shell nanostructures with an average RF resin shell size of RF ~31 nm.

We deposited Au nanoparticles on the surface of Te@RF. Hybrid nanostructures was performed towards the reduction of Au^{3+} with $NaBH_4$. Firstly, an aqueous solution of $NaBH_4$ was mixed with the Te@RF nanocables. Borohydrate ions could adsorb on the surface of RF resin. Upon addition of Au^{3+} ions, small crystalline Au nanoparticles were instantaneously produced on the surface of Te@RF nanocables as shown in Figure 1C. The Au nanoparticles were quasi-spherical in shape and had a broad distribution size in the range of 2-10 nm as shown in the inset of Figure 1C. In Figure 1D, the UV-vis absorption spectra of the nanocomposite show two main absorption bands at 290 and 514 nm associated with π-π* transitions of aromatic rings from RF resin and plasmon band of Au nanoparticles. One can notice that it is not possible to observe the absorption band of Te nanohelices. Probably, Te was eventually oxidized with the addition of Au^{3+} ions. The reduction of Au^{3+} ions on the surface of Te@RF nanocables endows to 1D nanostructures with homogeneously distributed small Au nanoparticles. One can propose that 1D nanostructures featuring multiple alternate layers of metallic nanoparticles and lanthanide compounds are feasible by using RF resin intermediate coating and may leverage further studies on the enhancement of luminescence, catalysis, photothermal phenomena, etc.

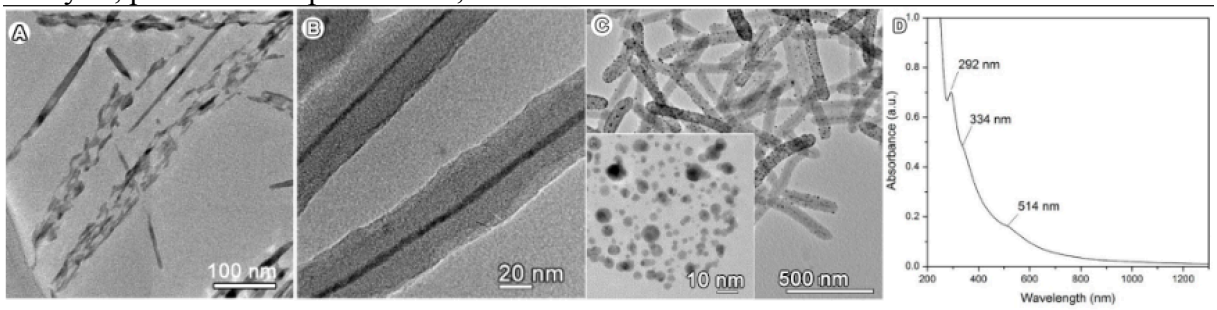

Figure 1. TEM images of A) Te nanohelix and B) Te@RF C) TEM images and UV-vis of Te@RF@Au nanostructures. Inset of C) shows the amplified TEM image of the tip of hybrid structure

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