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Sol-gel complements conventional strategies for the synthesis of self-extinguishing hybrid silica-epoxy nanocomposites

Empa Materials Science and Technology

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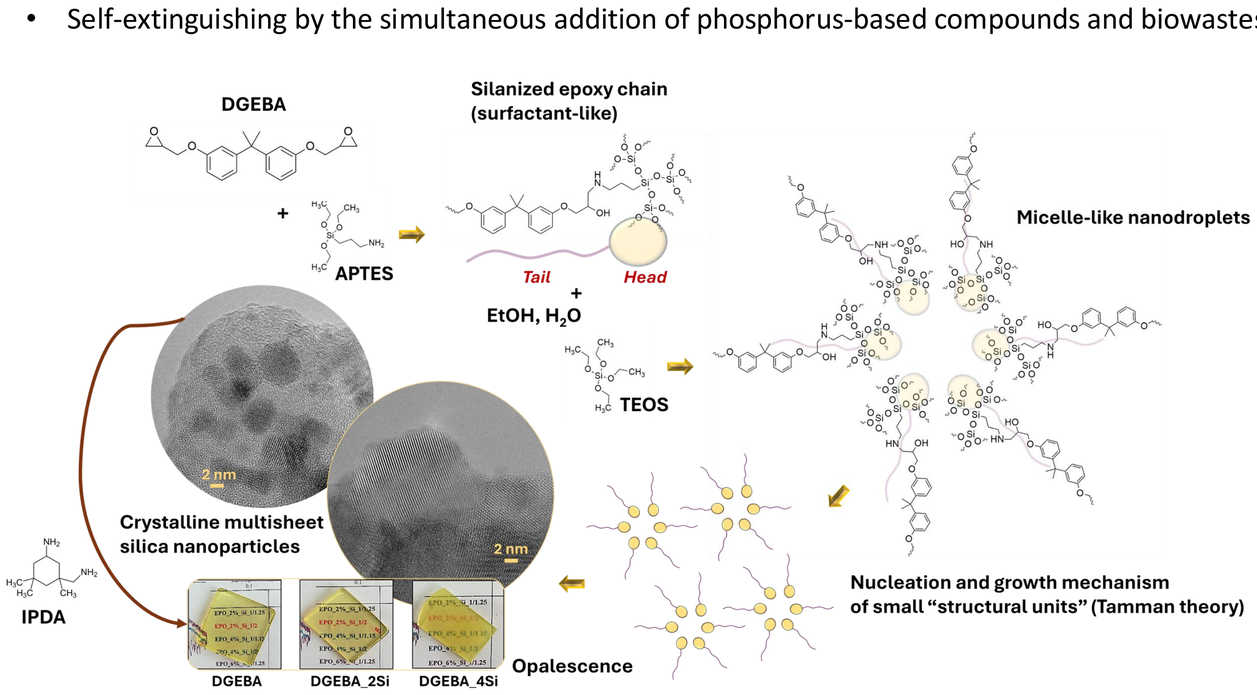
INTRODUCTION & AIM

State of art: In Situ Silica DGEBA Epoxy Hybrid Nanocomposites

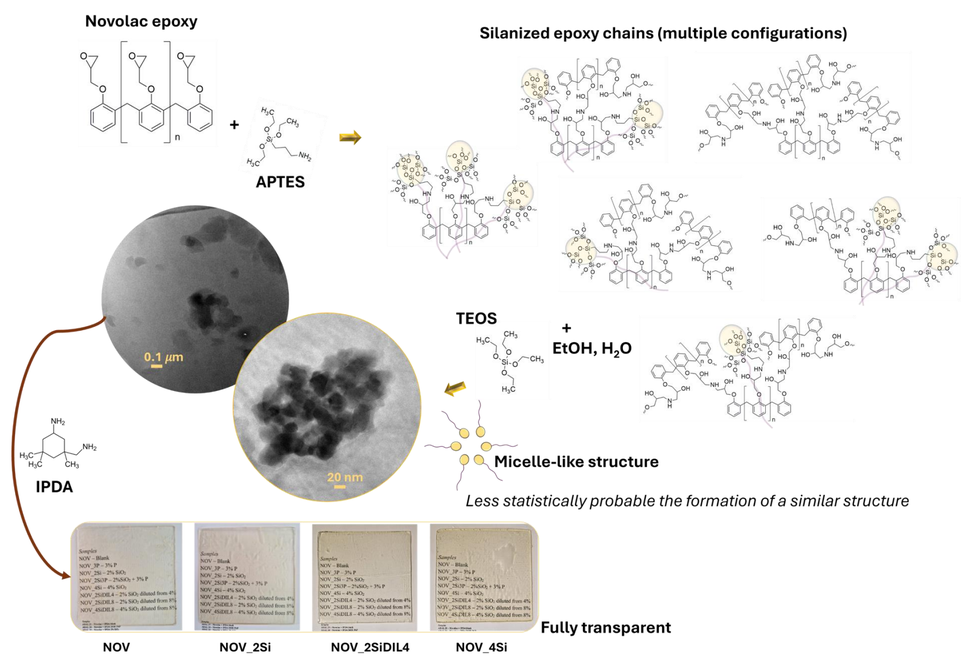
- The modification of DGEBA units with APTES leads to silanized epoxy chains
- Surfactant-like molecules arrange in micelle-like nanodroplets
- No dripping in UL-94 vertical flame test and ~40% HRR reduction with only 2 wt.% of silica
- Self-extinguishing by the simultaneous addition of phosphorus-based compounds and biowastes



METHOD

Proposed mechanism for the formation of Silica Novolac Epoxy Hybrid Nanocomposites

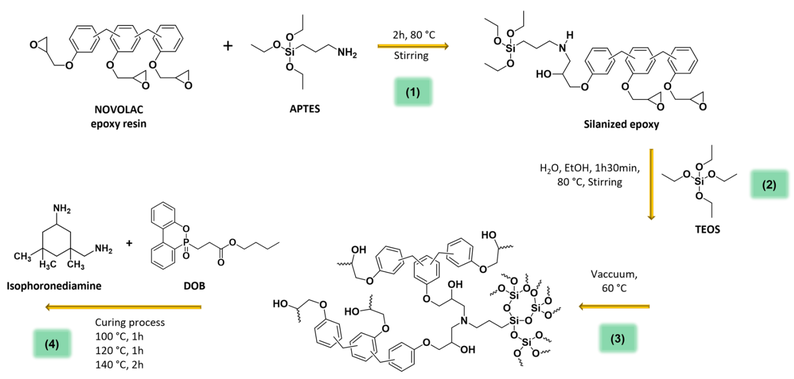
- HRTEM images reveal the presence of amorphous silica nanoparticles and the absence of visible crystalline lattices, even at high magnifications



Results in this poster are currently under review for publication

RESULTS & DISCUSSION

Synthesis and characterization of in-situ silica-epoxy nanocomposites

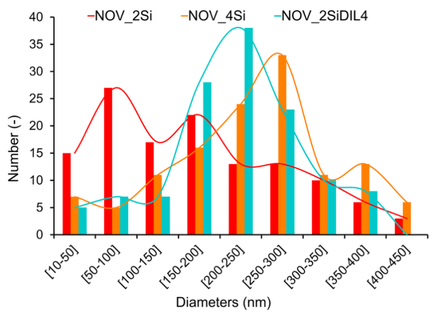


Sample	P (wt.%)	UL-94 class	Drip
NOV	-	NC*	Yes
DGEBA	-	ND**	
NOV_2Si	-	NC*	No
DGEBA_2Si	-	ND**	
NOV_2SiDIL4	-	ND**	
NOV_2SiDIL8	-	ND**	
NOV_4Si	-	ND**	
DGEBA_4Si	-	ND**	
NOV_4SiDIL8	-	ND**	
NOV_2P	1.94	NC*	No
NOV_2Si2P	1.91	NC*	No
NOV_3P	2.88	V1	No
NOV_2Si3P	2.90	V0	No

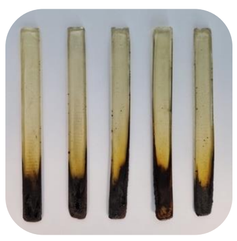
*non classifiable
**not done

- The dilution by the addition of fresh Novolac resin into the polymer matrix of NOV_4Si improves the dispersion of the silica nanoparticles
- Due to the amorphism of nanoparticles, the use of Novolac resin enables the manufacturing of fully transparent nanocomposites with a transmittance of ~80%

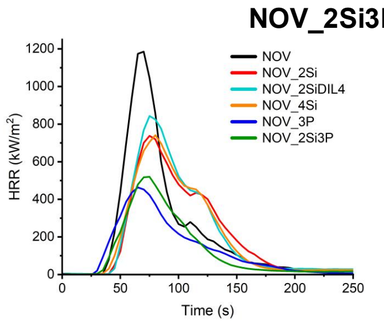
- NOV_2SiDIL4 shows a finer and wider dispersion of amorphous nanoparticles than NOV_4Si, with a mode diameter in the range of 200-250 nm



- Strong condensed phase action and char-forming role exerted by the silica nanoparticles
- DOB is most likely active in the gas phase by inhibition mechanism



Sample	TTI (s)	ΔTHR (%)	ΔpHRR (%)	TSR (m^2/m^2)	CO/CO_2 (-)
NOV	40 ± 1	-	-	1539 ± 23	0.09
NOV_2Si	41 ± 2	4	-30	1324 ± 6	0.07
NOV_2SiDIL4	44 ± 2	29	-31	1318 ± 36	0.07
NOV_4Si	39 ± 4	9	-36	1324 ± 17	0.06
NOV_3P	31 ± 3	-39	-60	2490 ± 66	0.32
NOV_2Si3P	35 ± 2	-34	-56	2127 ± 19	0.31



CONCLUSION AND FUTURE WORKS

- Sol-gel chemistry allows for synthesizing fully transparent hybrid silica-epoxy nanocomposites containing in-situ generated silica nanoparticles
- The incorporation of a liquid P-based compound with 2 wt.% of silica allows for the preparation of no dripping self-extinguishing (UL94-V0 rating) nanocomposites, even with only 3 wt.% of P
- The developed Novolac-based silica-epoxy nanocomposites may pave the way for the future synthesis of more advanced polymeric materials with high clarity for demanding visual applications

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