

Influence of Thiol-Functionalized Polysilsesquioxane/Phosphorus Flame-Retardant Blends on the Flammability and Thermal, Mechanical, and Volatile Organic Compound (VOC) Emission Properties of Epoxy Resins

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Figure S1a,b presents similar ¹H NMR spectra for synthesized TFLPM and TFLPP, confirming the successful grafting of mercaptopropyl arms through characteristic peaks. Four signals in the spectra correspond to the mercaptopropyl chain repeat unit: methylene protons (a, b, c) and the thiol proton (d). Additionally, the TFLPM spectrum exhibited peaks at δ 0.07–0.12 ppm, attributed to the Si-CH₃ group. The TFLPP spectrum exhibited peaks at δ 7.38–7.56 ppm, attributed to the Si-PH group. Calibration with CDCl₃ solvent yielded a peak chemical shift [δ] of 7.3 ppm.

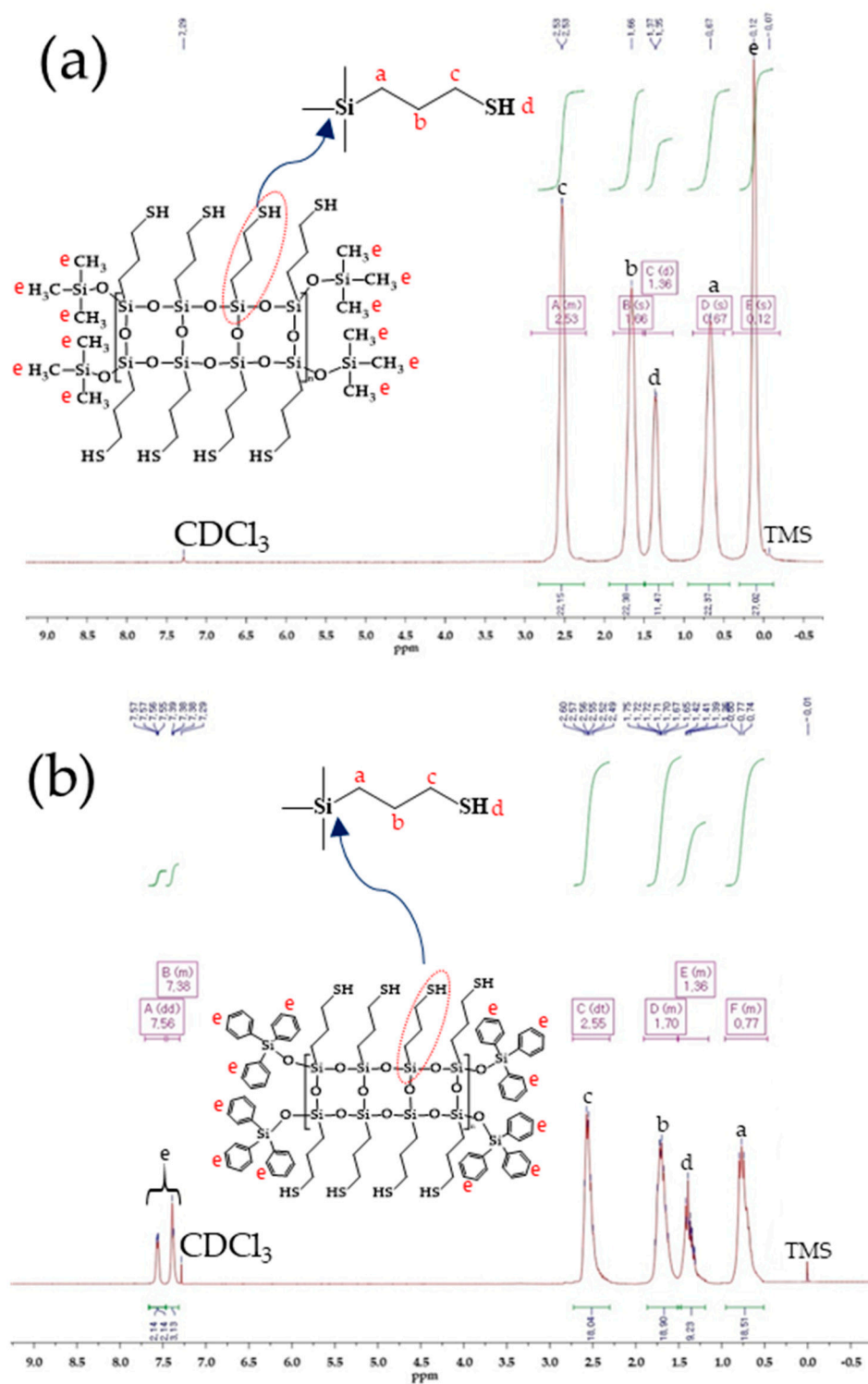


Figure S1. ^1H NMR Spectra of (a) TFLPM and (b) TFLPP.

Consistent with the ^1H NMR findings, the ^{13}C NMR spectra of TFLPM and TFLPP in Figure S2a,b exhibit peaks confirming the presence of grafted mercaptopropyl arms. In both TFLPM and TFLPP, two signals corresponding to methylene carbons a and b, c were assigned to the mercaptopropyl repeating unit. The TFLPM spectrum exhibited a peak at δ 1.44 ppm due to the Si-CH₃ group, while TFLPP presented peaks at δ 127.82 (ortho-C), δ 130.28 (para-C), and δ 134.06 ppm (meta-C) arising from the presence of phenyl groups. The 77 ppm triplet observed in the ^{13}C NMR spectrum indicates coupling between the carbon of the solvent CDCl₃ and deuterium ($I = 1$).

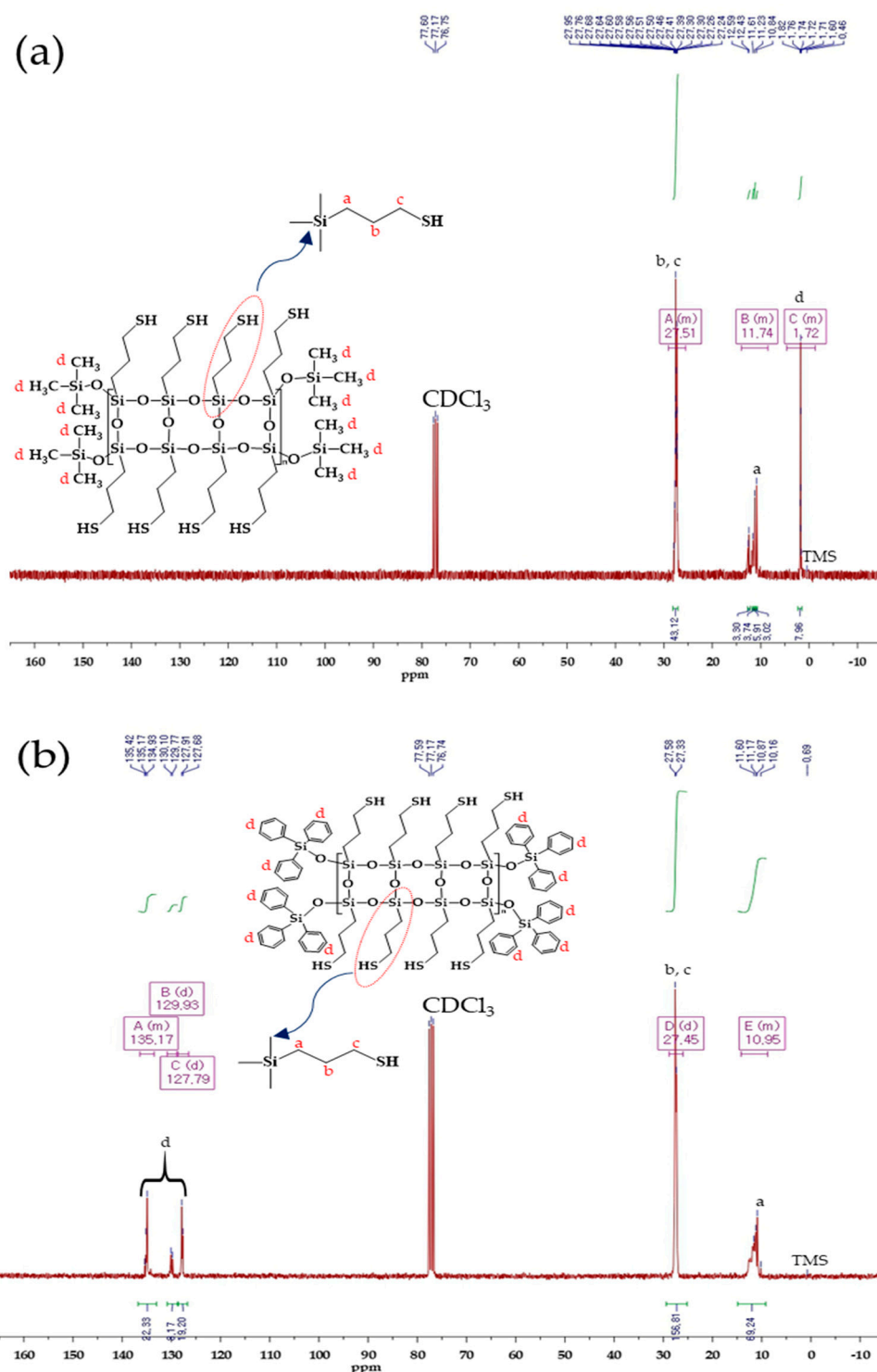


Figure S2. ^{13}C NMR Spectra of (a) TFLPM and (b) TFLPP.

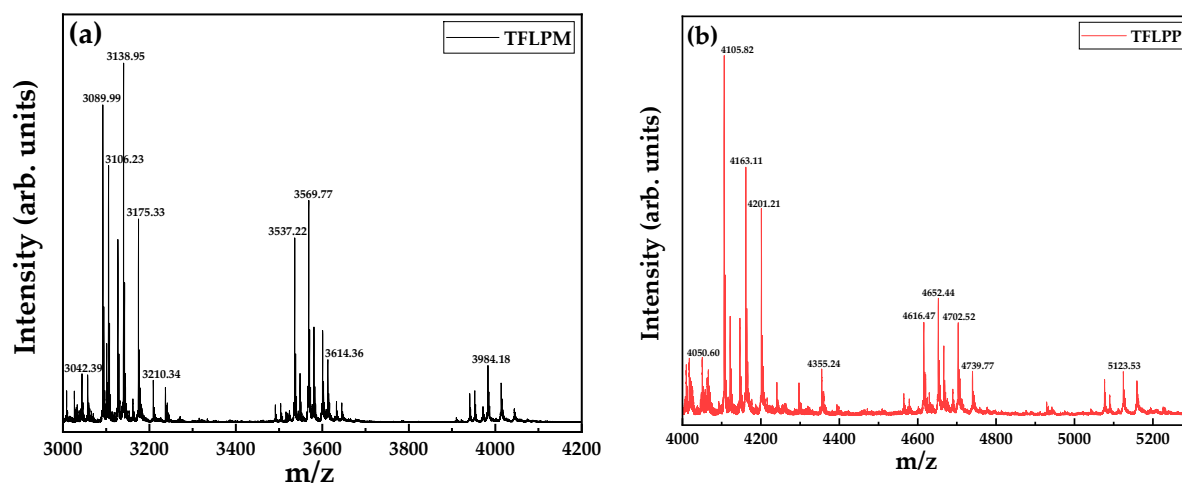


Figure S3. MALDI-TOF MS spectra of (a) TFLPM and (b) TFLPP.

Table S1. Specific requirements of the UL 94 V test

Criteria	Category		
	V-0	V-1	V-2
Burning time of each individual test specimen	≤10 s	≤30 s	≤30 s
Total after flame time for any condition set [5 flame applications]	≤50 s	≤250 s	≤250 s
Individual test specimen after flame plus afterglow time after the second flame application	≤30 s	≤60 s	≤60 s
Dripping of burning specimens [ignition of cotton batting]	No	No	Yes
Combustion up to holding clamp [specimens completely burned]	No	No	No