Functionalization of Powder and Fibrous Microfillers for UHMWPE by Treatment with Polyorganosiloxane

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To develop higher strength and wear-resistant polymer composites, which are based on the ultra-high molecular weight polyethylene (UHMWPE), the mechanical and tribotechnical characteristics of UHMWPE filled with wollastonite microfibers and aluminum metahydroxide AlO (OH) microparticles preliminary treated (functionalized) in polyorganosiloxane to increase the adhesion of the fillers to the matrix have been studied. The choice of fillers and the adhesion promoter for the ultra-high molecular weight matrix is determined by the search of effective commercially available fillers and surface modifiers to design wear resistant polymeric composites for friction units in mechanical engineering. Chemical and permolecular structure, wear track surface topography of UHMWPE composites have been investigated under dry sliding friction at different loads and sliding velocities.

TABLE 1. Physical and mechanical properties of UHMWPE and its composites

Content of the filler, wt %	Density ρ, g/cm³	Shore hardness D	Elastic modulus E, MPa	Yield point $\sigma_{0.2}$, MPa	Ultimate strength σ_U, MPa	Elongation at break ε, %
UHMWPE	0.928	55.6 ± 0.2	405 ± 17	22.1 ± 0.4	36 ± 1.6	482 ± 6
UHMWPE + 20 wt % Wollast	1.062	58.9 ± 0.7	501 ± 30	24.7 ± 1.1	36.8 ± 5.7	454 ± 60
UHMWPE + 20 wt % Wollast. + 0.2% Penta 1006 (hydrolysis)	1.062	59.19 ± 0.6	620 ± 46	25.2 ± 1.3	34 ± 4	415 ± 23
UHMWPE + 20 wt % Wollast. + 0.2 wt % Penta 1006	1.062	59.10 ± 0.5	484 ± 26	22.4 ± 0.8	34.5 ± 1.2	424 ± 55
UHMWPE + 20 wt % AlO(OH)	1.07	60.23 ± 0.6	509 ± 55	21.9 ± 1.3	33.2 ± 1.9	425 ± 39
UHMWPE + 20 wt % AlO(OH) + 0.2% Penta 1006 (hydrolysis)	1.064	59.4 ± 0.5	564 ± 19	23.1 ± 0.5	37.0 ± 1.5	446 ± 26

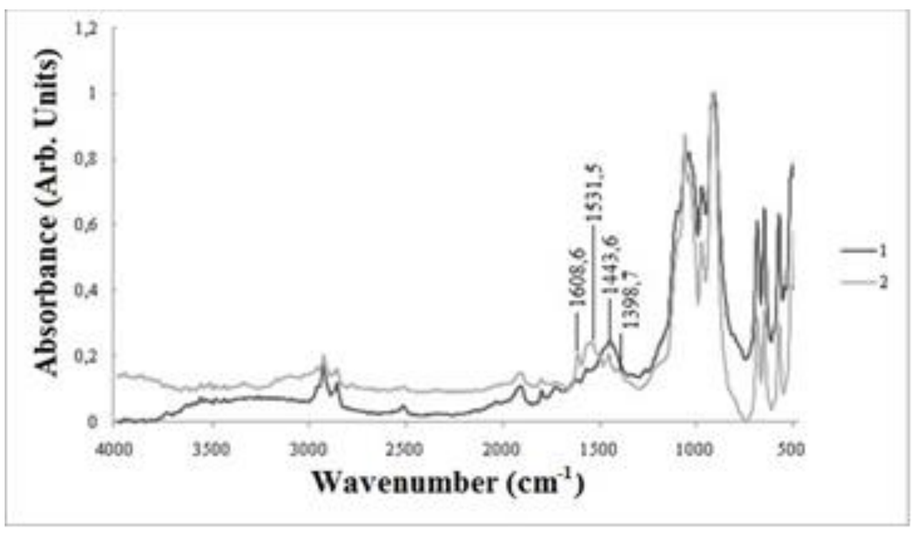
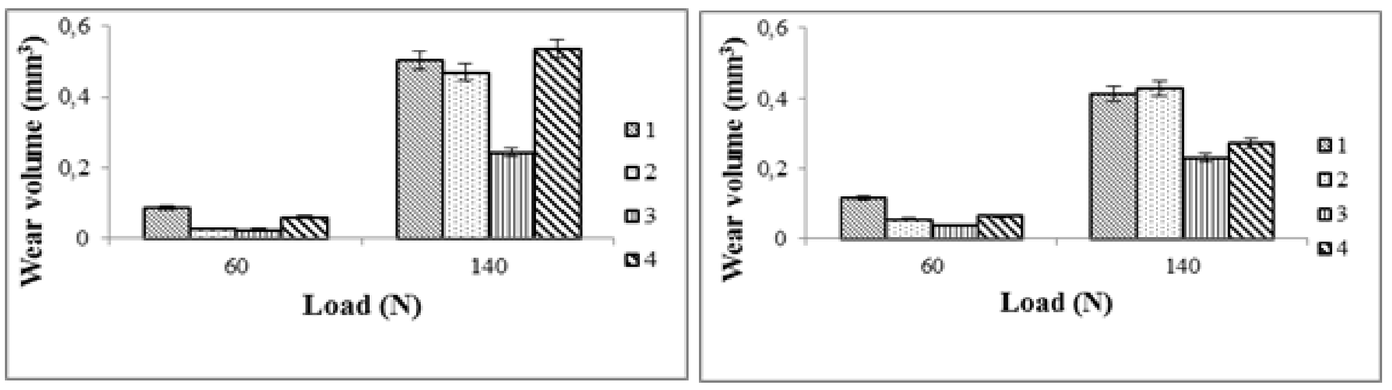


FIGURE 1. IR-spectra of the UHMWPE–wollastonite composite with 0.2 wt % of polyorganosiloxane: without (*1*) and after hydrolysis (*2*)



a b

FIGURE 3. Volumetric wear (mm³) at sliding velocities V = 0.3 (a) and 0.5 m/s (b) of UHMWPE (1) and its composites with 20 wt % of wollastonite (2), UHMWPE + 20 wt % of wollastonite + 0.2 wt % Penta 1006 with hydrolysis (3) and UHMWPE + 20 wt % of wollastonite + 0.2 wt % Penta 1006 without hydrolysis (4) at the loads P = 60 and 140 N

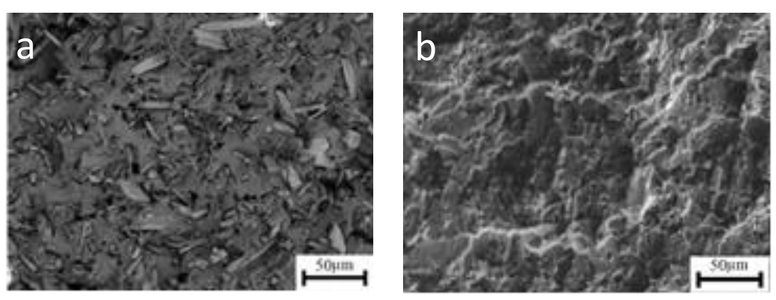
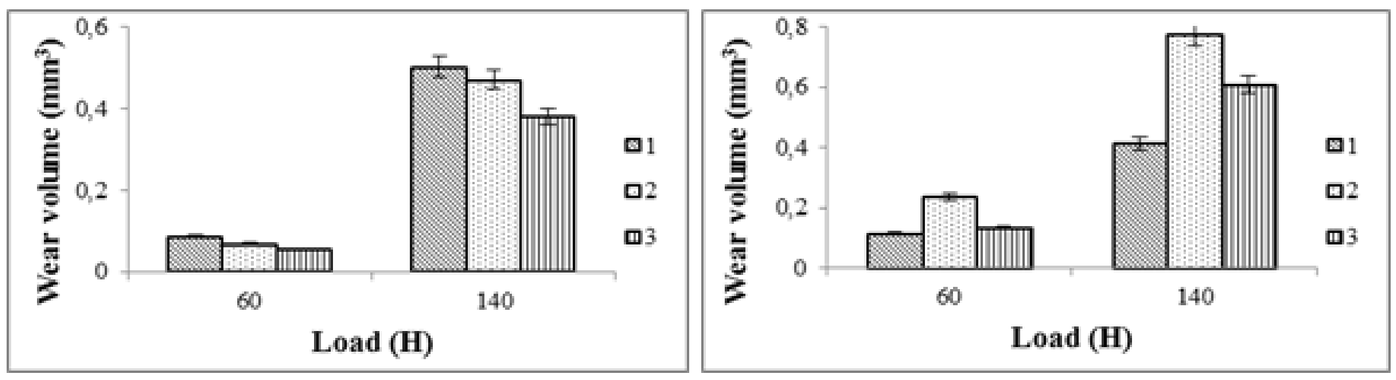


FIGURE 2. Permolecular structure of UHMWPE loaded with 20 wt % of wollastonite (a), 20 wt % AlO (OH) (b)



a b

FIGURE 4. Volumetric wear (mm³) at the sliding velocities *V* = 0.3 (a) and 0.5 m/s (b) of the UHMWPE (*1*) and its composites UHMWPE + 20 wt % AlO (OH) (*2*), UHMWPE + 20 wt % AlO (OH) + 0.2 wt % Penta 1006 with hydrolysis (*3*) at loads *P*=60 and 140 N

CONCLUSION

The physical, mechanical and tribotechnical properties of UHMWPE composites with functionalized fiber and powder microfillers at different sliding velocities (*V* = 0.3 and 0.5 m/s) and loads (*P* = 60 and 140 N) under dry sliding friction have been studied. It is shown that the treatment of the fibrous and powder fillers by the polyorganosiloxane with initiating the hydrolysis process increases the mechanical characteristics of composites based on the high molecular weight PE matrix by 10%. The wear resistance of the microcomposites increases twofold at sliding velocities *V* = 0.3 m/s and 0.5 m/s at the moderate load (*P* = 60 N) as compared to the pure UHMWPE. When the load is increased up to *P* = 140 N, the wear resistance of the composites is sharply reduced. For this reason, micro-composites UHMWPE based with the functionalized fibrous and powder fillers can be recommended for operation in friction units over a wide range of sliding velocities (up to *V* = 0.5 m/s) and at the moderate loads up to *P* = 60 N. The technique for compatibilizing mineral fillers (fibrous and powder) with the high molecular weight PE matrix by the treatment in the polyorganosiloxane can be applied as an efficient approach for increasing the wear resistance of highly filled UHMWPE composites.