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Austin, D, Hassanpour, A orcid.org/0000-0002-7756-1506, Hunter, TN orcid.org/0000-0003-3922-491X et al. (4 more authors) (2022) Role of sodium hexametaphosphate in ultra-fine grinding of alumina-doped titanium dioxide. Powder Technology, 397. 117022. ISSN 0032-5910

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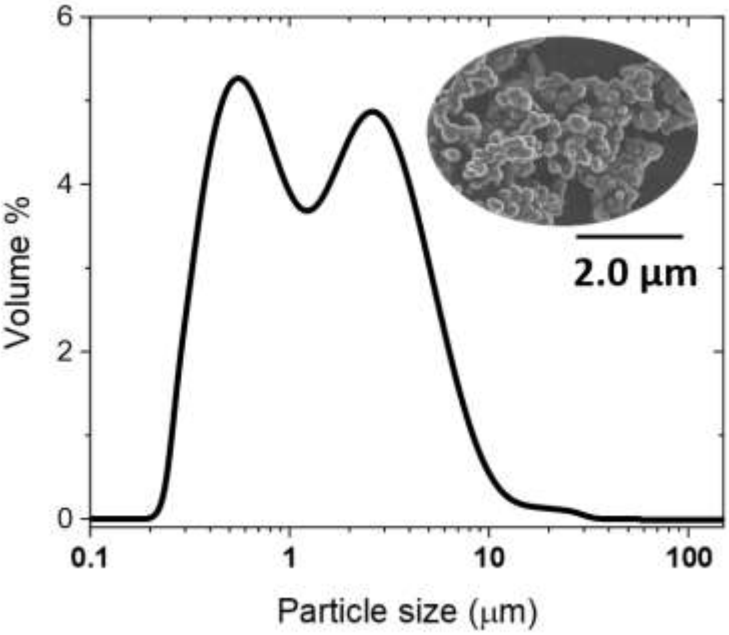

Figure 1. Particle size distribution of the as-received Al-doped TiO_2. A suspension of 0.05 vol% was prepared in 10^{-3} M NaCl, adjusted to pH 4. Inset: scanning electron microscope image of the dried Al-doped TiO_2 sample.

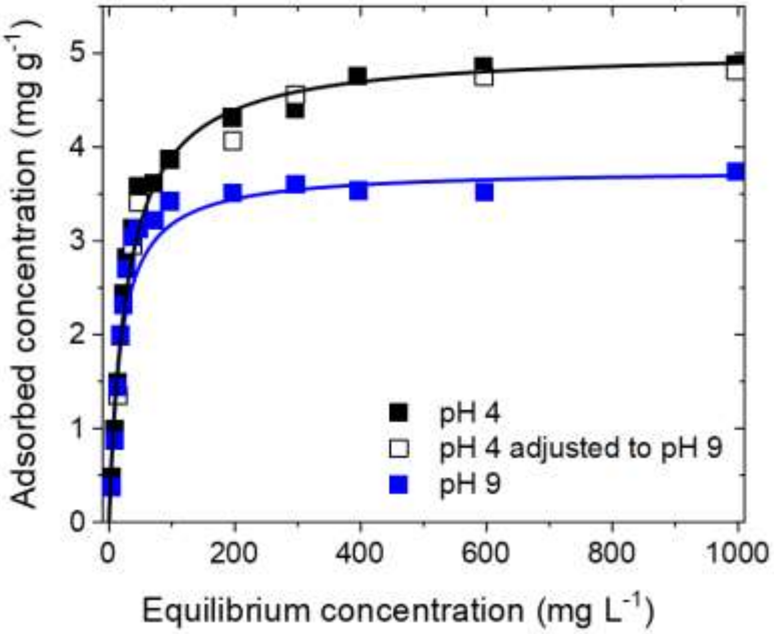

Figure 2. Adsorption isotherms of SHMP on Al-doped TiO_2. Closed symbols represent SHMP adsorption at pH 4 (black) and pH 9 (blue), while open symbol represents SHMP adsorption at pH 4 and adjusted to pH 9. The lines show the Langmuir fits at pH 4 and pH 9.

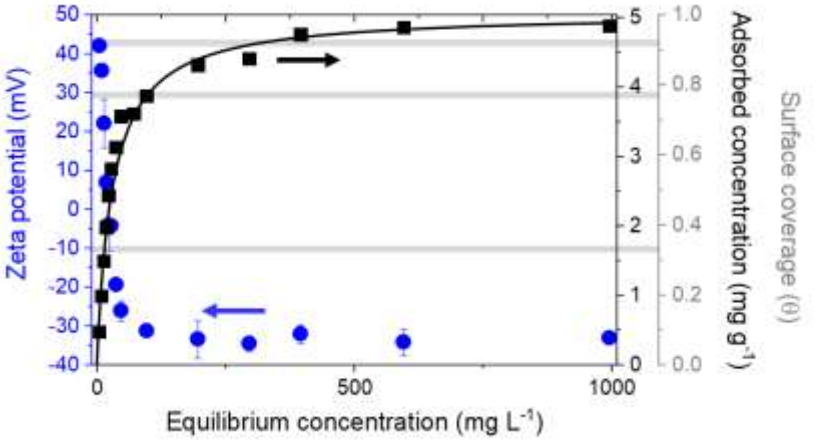

Figure 3. SHMP adsorption isotherm on Al-doped TiO_2 at pH 4 in 10^{-3} M NaCl and the corresponding particle zeta potential at pH 4.

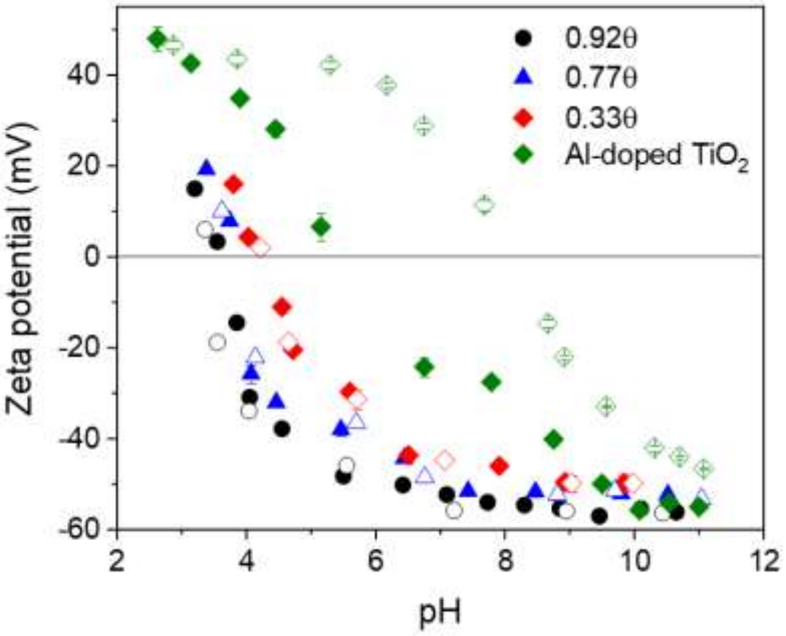

Figure 4. pH-dependent particle zeta potentials before (closed symbols) and after (open symbols) milling with SHMP dose concentrations of 0.16 wt% (0.33θ), 1 wt% (0.77θ) and 3.5 wt% (0.92θ). The mill conditions were 60 min at 6000 rpm.

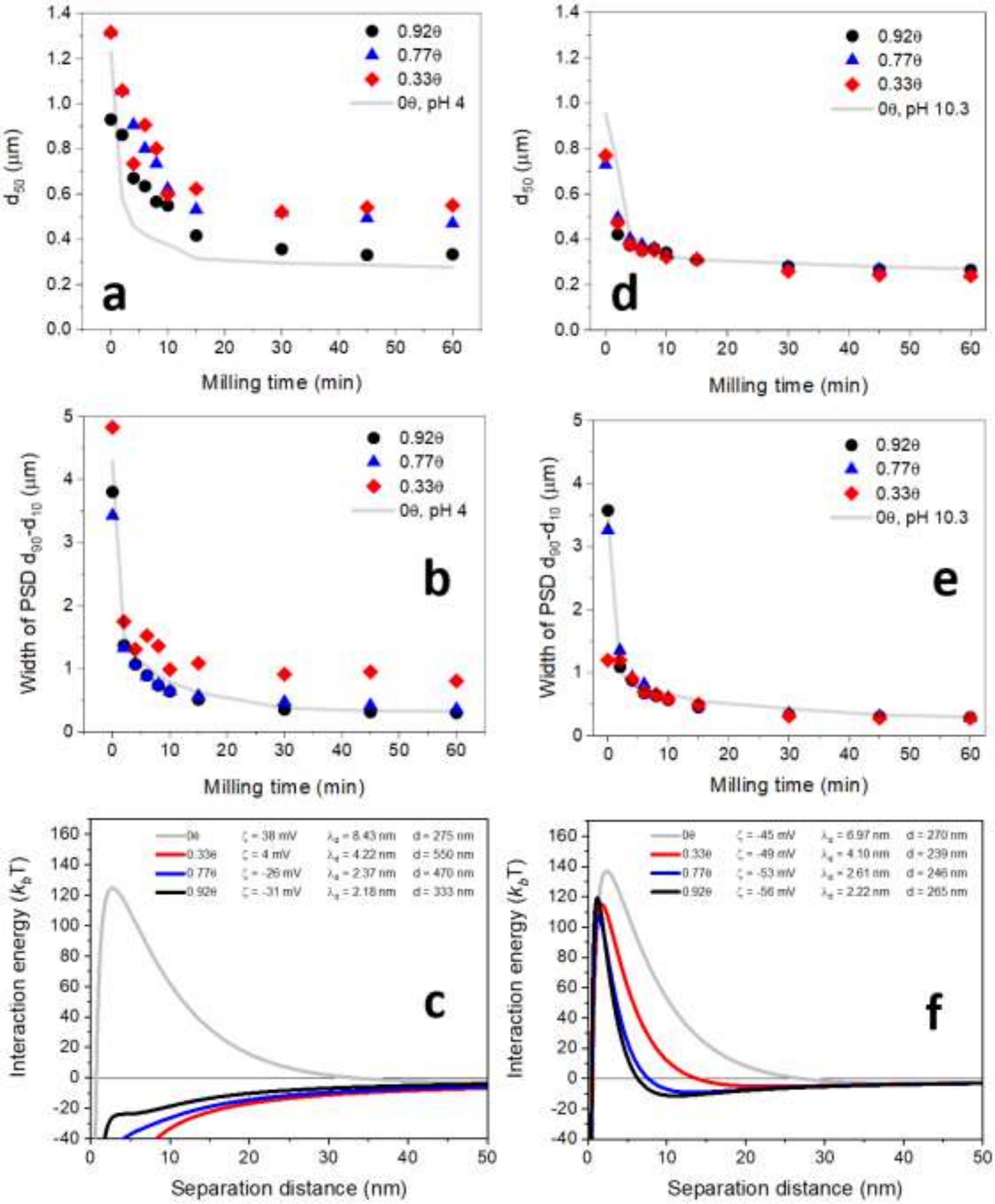

Figure 5. The apparent milling performance of 5 vol% Al-doped TiO_2 in 10^{-3} M NaCl at pH 4 and pH 10.3, milled at 6000 rpm for up to 60 min. The initial dose concentrations of SHMP were such that the adsorbed surface coverages were 0, 0.33, 0.77 and 0.92θ. The particle size is represented by the d_{50} value and the particle size distribution by the d_{90}-d_{10} value. The theoretical particle-particle interaction energies were calculated using Eq. 5, with the zeta potentials taken from Fig. 4, and the Debye lengths determined from the measured solution conductivity.

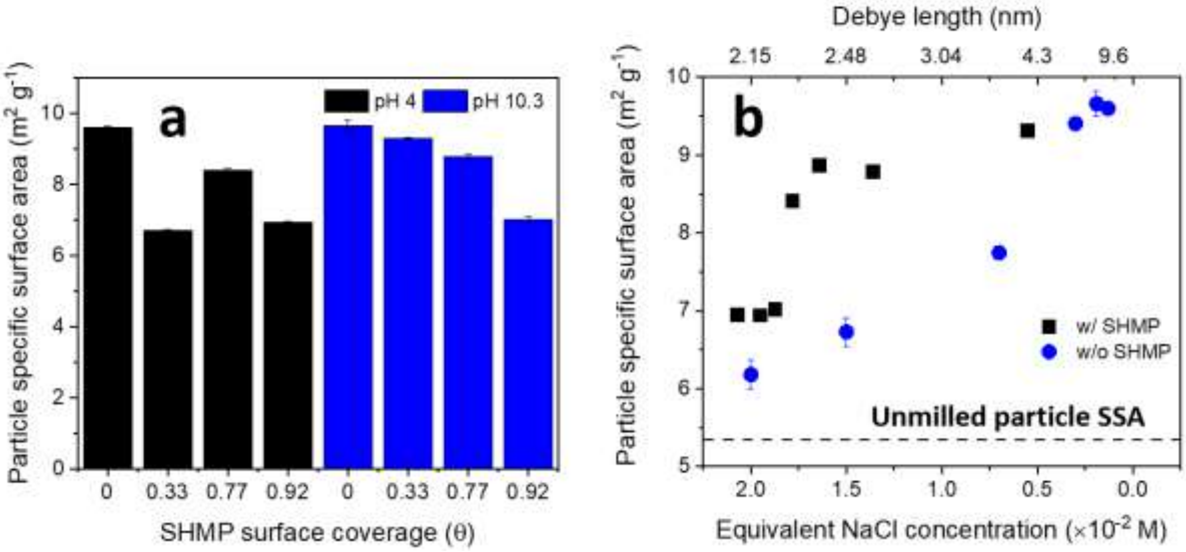

Figure 6. a) The particle specific surface area (SSA) of Al-doped TiO_2 milled at 5 vol% in 10^{-3} M NaCl at pH 4 and pH 10.3 for 60 min at 6000 rpm. The initial dosing concentrations of SHMP led to adsorbed surface coverages of 0, 0.33, 0.77 and 0.92θ. b) Comparing the particle SSA as a function of the equivalent concentration of NaCl (× 10^{-2} M). The data points with SHMP correspond to the samples in (a), and without SHMP the background electrolyte concentration (NaCl) was increased. The data are compared for milling at 6000 rpm and 60 min. The corresponding Debye length for the electrolyte concentration is shown on the X_2-axis. It is important to note the correlation between Debye length and equivalent electrolyte concentration is non-linear. Therefore, only at those Debye lengths plotted are the values absolutely correct.

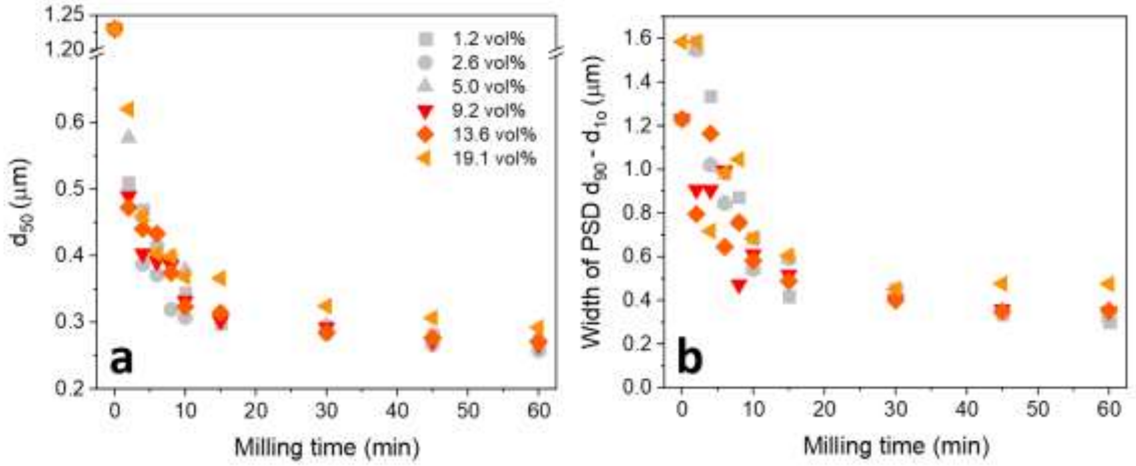

Figure 7. The effect of solids concentration on the apparent milling performance of Al-doped TiO_2 in 10^{-3} M NaCl at pH 4, milled at 6000 rpm for up to 60 min. The particle size is represented by the d_{50} value (a) and the width of PSD (d_{90}-d_{10}) (b). The solids concentration range was 1.2 vol% to 26.2 vol%, with the increments shown in the data legend. All samples were milled without SHMP. The data for 1.2 to 5.0 vol% are greyed-out as they represent solids concentrations below those of industry relevance, but are included to further demonstrate the milling behavior.

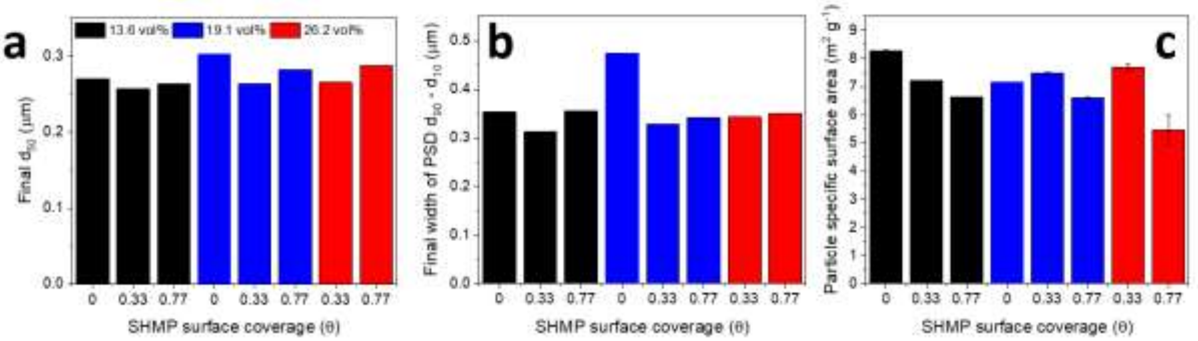

Figure 8. The effect of solids concentration (13.6, 19.1 and 26.2 vol%) and SHMP dosing concentration (0, 0.33 and 0.77θ) on the apparent (a and b) and true (c) milling performance of Al-doped TiO_2 in 10^{-3} M NaCl at pH 10.3, milled at 6000 rpm for 60 min. The particle size data is represented by the d_{50} value (a), the particle size distribution (d_{90}-d_{10}) (b), and the particle SSA (c). N.b. the control sample without SHMP was milled at pH 4. Such comparison is valid as the magnitude of zeta potential at pH 4 (|38| mV) is equivalent to that at pH 10.3 (|45| mV), see Fig. 4.

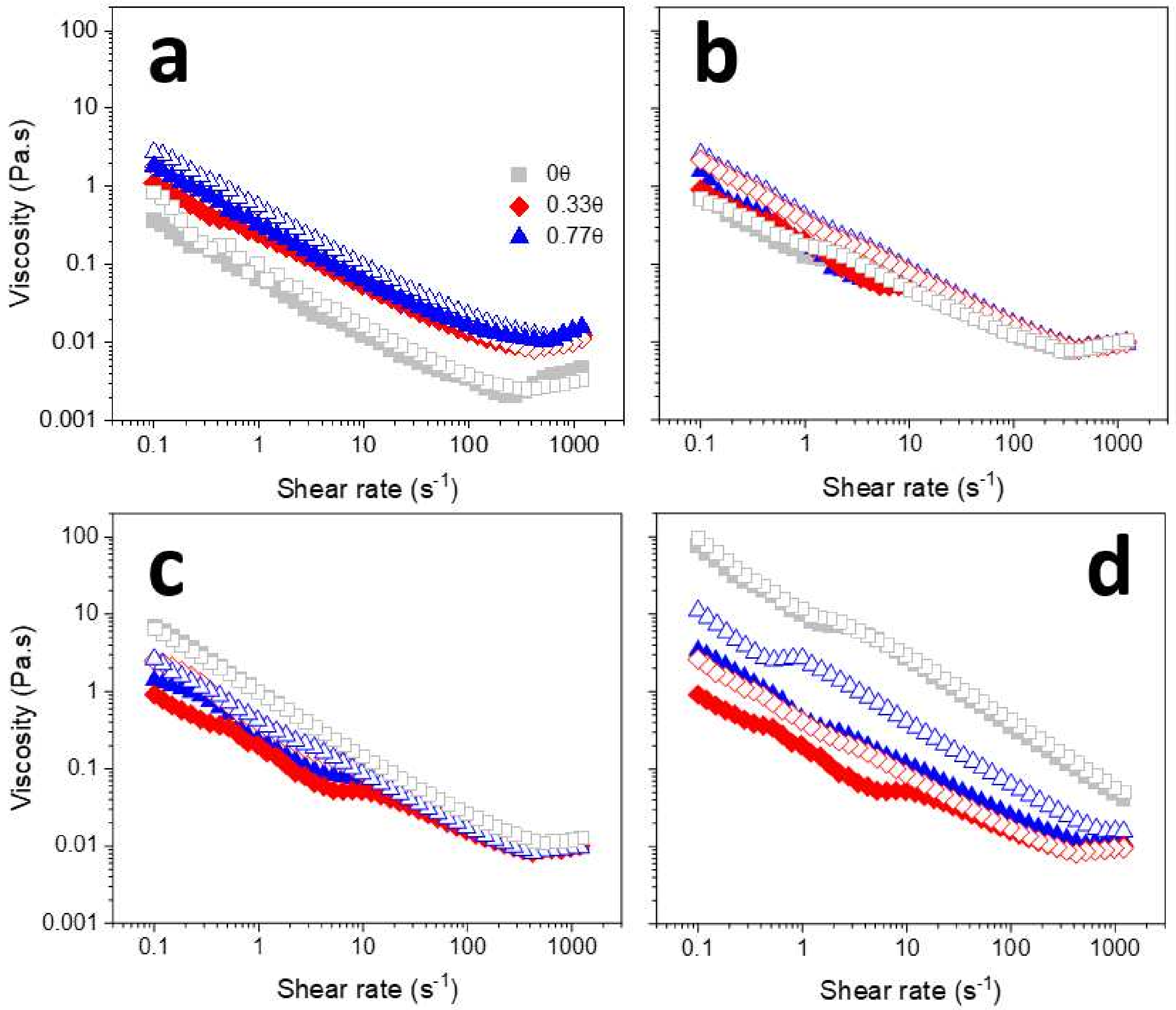

Figure 9. The rheology of Al-doped TiO_2 suspensions in 10^{-3} M NaCl. The SHMP dose concentrations were equivalent to 0θ, 0.33θ and 0.77θ. Suspensions without and with SHMP were at pH 4 and pH 10.3. The solids concentration was fixed at 19.1 vol%. The milling times were varied: 0 min (a), 6 min (b), 15 min (c) and 60 min (d). The rheology data collected for the first and last shear rate ramp are shown by the closed and open symbols, respectively.