

## **The role of polymer in dispersion stability and film formation of silica/PVA suspension**

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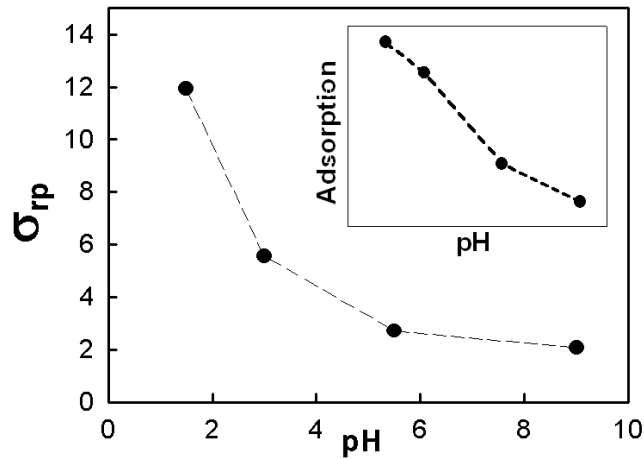
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Film formation of particle/binder/solvent system is of importance in various applications to produce battery, display, electronic components and so on. Because dispersion stability is a crucial issue for defect-free final products, many attempts have been carried out to analyze and control the microstructure of the suspension. In this study, The effect of polymers on dispersion stability and film formation of particle/polymer suspension was investigated in terms of particle/polymer affinity, adsorption kinetics. Silica/poly(vinyl alcohol) suspension was used as a model suspension. Suspension microstructure and stress development during drying[1] were characterized and their relationship was investigated.

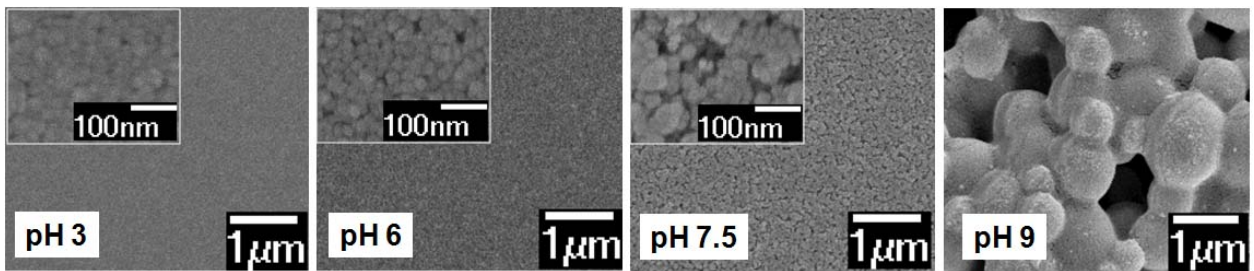
The effect of particle/polymer affinity on microstructural change during drying of silica/PVA suspension was studied by changing pH from 1.5 to 9[2]. As shown in the inset of Figure 1, the amount of adsorption was measured to increase with decreasing pH, and the degree of flocculation in silica/PVA suspension became stronger with decreasing pH. However, through measurement of stress development during drying (Figure 1) and observation of film microstructure after drying (Figure 2), it was found that more strongly flocculated suspension became more dispersed and close-packed film after drying. In order to explain the structural change during drying, the following drying mechanism was suggested based on the evaluation of potential energy (Figure 3). As pH decreases, the adsorbed polymers could bridge the particles and lead to flocculated suspension before drying. As the solvent evaporates during drying, the adsorbed polymers introduce steric repulsion between approaching particles, leading to a change from flocculated to dispersed microstructure.

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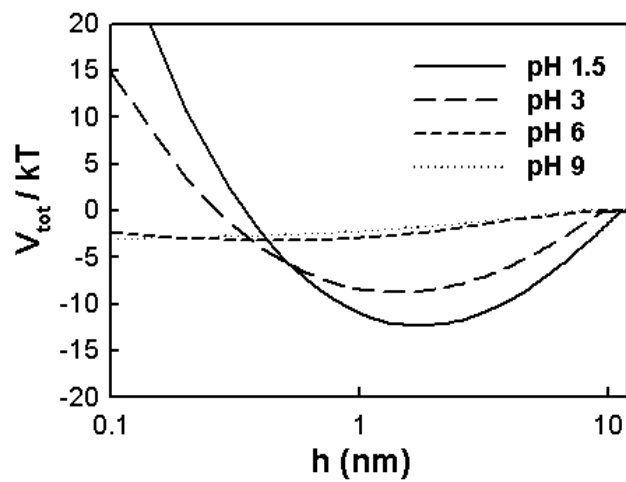
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**Figure 1.**  $\sigma_{ch}$  Relative plateau stress of silica/PVA suspension (●). Inset: the amount of PVA adsorbed on silica surface in silica/PVA suspension from pH 1.5 to 9

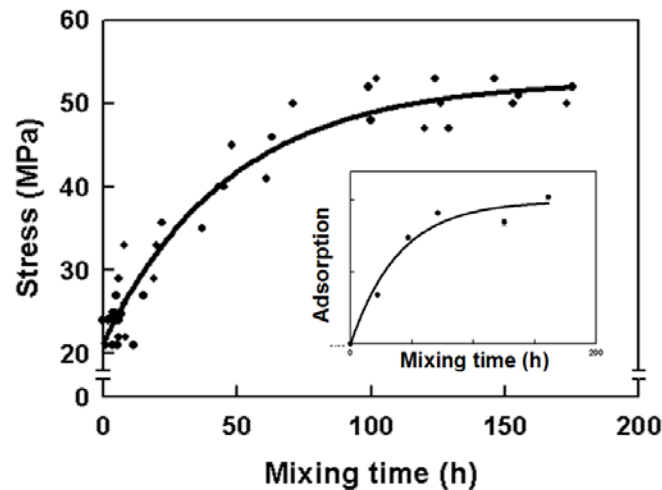


**Figure 2.** SEM images of dried film surface prepared from silica/PVA suspension with varied pH

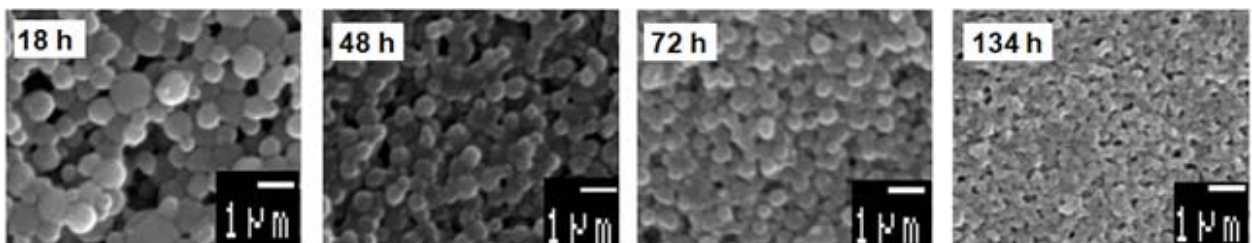


**Figure 3.** The total potential energy ( $V_{tot}$ ) with particle separation ( $h$ ) for silica/PVA suspension with various pH.

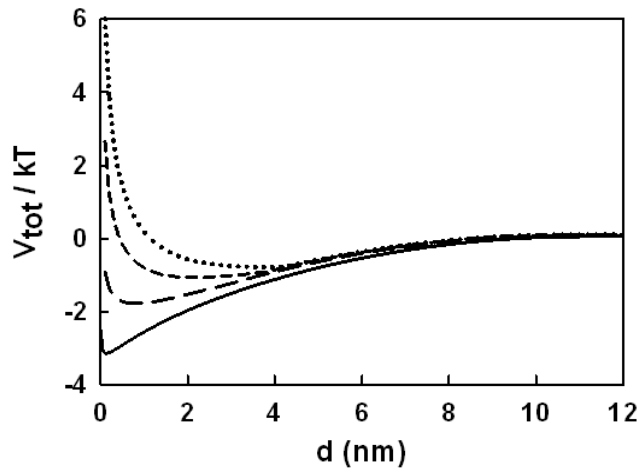
The effect of adsorption kinetics on film formation was studied by changing the mixing time ( $t_m$ )[3]. In terms of mixing (or dispersion) time ( $t_m$ ), the adsorption amount in the inset of figure 4, characteristic stress ( $\sigma_{ch}$ ) in figure 4 showed a similar behavior in the form of  $1 - e^{-t_m/\tau}$  with a single characteristic time  $\tau=45$  h which implies that the drying process is determined by this simple characteristic equation with a single time constant. As shown in figure 5, the porous and non-uniform microstructure of the dried film at short  $t_m$  became close-packed and uniform microstructure with longer  $t_m$ . Evaluation of particle interaction in figure 6 led to the possibility that the adsorbed polymer introduces steric repulsion in the suspension and suppresses flocculation during solvent evaporation. It was also pointed out that enough mixing time for the saturated polymer adsorption is critical to acquire the consolidated and uniform film microstructure.



**Figure 4.** Maximum stress of Silica / PVA suspension with mixing time. measured value (●) and its regression curve(---). Inset: amount of PVA adsorption on silica surface with mixing time. Measured value(●) and its regression curve(-)



**Figure 5.** SEM image of dried silica/PVA suspension film surface at different mixing time.



**Figure 6.** Total potential energy ( $V_{tot}$ ) as a function of particle separation  $d$  at various  $t_m$ .  
 $t_m =$  (—) 24 h, (---) 47 h, (- -) 71 h, (···) 161 h.

This work proves that the particle/polymer film can be tailored by controlling the amount of polymer adsorption in the suspension. It is expected to contribute to industry by providing the useful insight in understanding the structural change of particle/polymer suspensions during drying process.

## References

- [1] S. Kim, J.H. Kim, K.H. Ahn, S.J. Lee, Rheological perspectives on industrial coating process, *Korea-Australia Rheology Journal*, 21 (2009) 83-89.
- [2] S. Kim, J.H. Sung, K.H. Ahn, S.J. Lee, Drying of the Silica/PVA Suspension: Effect of Suspension Microstructure, *Langmuir*, 25 (2009) 6155-61.
- [3] S. Kim, J.H. Sung, K. Hur, K.H. Ahn, S.J. Lee, The effect of adsorption kinetics on film formation of silica/PVA suspension, *Journal of Colloid and Interface Science*, 344 (2010) 308-14.