Study of asphaltene adsorption on solid surfaces using QCM

Atoosa Zahabi[a*], Murray R. Gray[a], Tadeusz Dabros[b]

[a]Department of Chemical and Materials Engineering, University of Alberta, Edmonton, Alberta, Canada, T6G 2V4
[b]CanmetENERGY, Devon, Alberta, Canada, T9G 1A8
([*]Corresponding Author: zahabi@ualberta.ca)

A quartz crystal microbalance (QCM) was used to measure asphaltene adsorption on gold surfaces and silica particles having different hydrophobicities. The adsorption studies were conducted at various ratios of pentane/oil solution (5 wt% pitch material in toluene) for two hours. Our previous work showed that the onset of asphaltene precipitation for 5 wt% pitch in toluene (45.6 kg/m^3) occurred at S/O=0.43 (pentane/oil solution) by weight. The results from QCM demonstrated that even below this S/O value, adsorption of asphaltenes and possibly other components on the surfaces of silica particles and other solid surfaces was detectable. The amount of material adsorbed increased significantly after the onset of asphaltene precipitation (Fig. 1). Adsorption was more pronounced on the gold surface than on the silica particles, especially after the onset of asphaltene precipitation (Fig. 2). Hydrophiliic silica particles adsorbed more material compared to hydrophoblic ones above the onset point; however, the adsorption amounts were similar below the onset point for both particles.

We also studied the kinetics of adsorption of asphaltenes on gold at room temperature. The results showed that aggregation of the asphaltenes occurred even for very dilute samples of asphaltenes in toluene. The initial rate of change of adsorbed mass is a linear function of the inverse of the square root of time according to

$$\frac{dm}{dt} = C\left(\frac{D}{\pi(t - t_s)}\right)^{1/2}$$

where *C* is the concentration of the species in the bulk, *m* is the adsorbed mass, *t* is the time, t_s is the time of immersion, and *D* is the diffusion coefficient, calculated from the initial slope. We calculate the size of the adsorbed particles using the Stokes-Einstein equation (Fig. 3):

$$d = \frac{K_B T}{3\pi\eta D}$$

where *d* is the particle size (m), K_B is the Boltzmann constant ($1.3806503 \times 10^{-23}$ $m^2 \cdot kg \cdot s^{-2} \cdot K^{-1}$), *T* is the temperature (K), and η is the kinematic viscosity of the liquid (Pa·s).

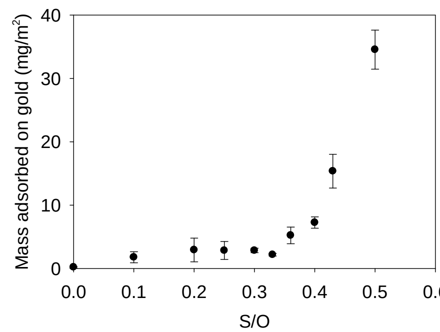

Fig. 1. Adsorption of asphaltenes and other components on gold at various S/O after washing with toluene for two hours using immersion method

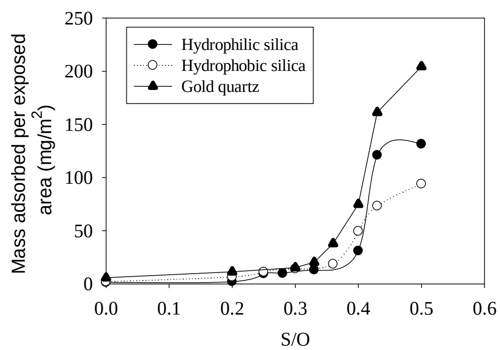

Fig. 2. Mass adsorbed per unit exposed area on hydrophobic and hydrophilic silica particles and gold-coated quartz crystal in a flow-through cell

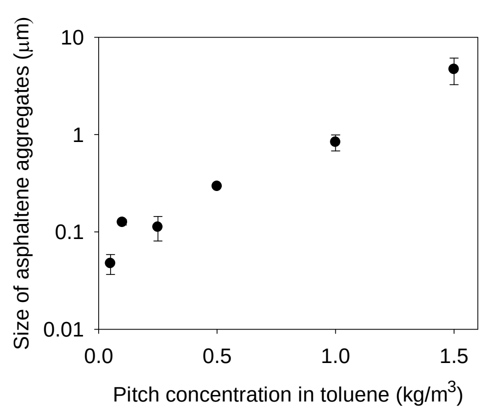

Fig. 3. Size of asphaltene aggregates at various concentrations of pitch in toluene