Numerical Studies on Liquid Drop Spreading and Dynamics on Porous Solids

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The spreading of liquid over porous solid surfaces like catalyst or column packings is very important in several fields of chemical engineering such as packed bed adsorbers and trickle bed reactors. The focus of this study is to have a better understanding of liquid drop spreading over porous surfaces that significantly affects the catalyst wetting efficiency. The catalyst wetting efficiency i.e., fraction of the external catalyst pellet area wetted by the flowing liquid is an important parameter as it gives an indication of the extent of catalyst utilization. Partial wetting where only a fraction of the catalyst pellet surface is wetted by the liquid always leaves scope for improvement in the wetting efficiency.

Based on the conceptual model proposed by Khanna and Nigam (2002), it has been illustrated that liquid spreading in porous solids is driven more by porosity than by contact angle. A major implication of this phenomenon is that liquid will spread more on less wettable (but porous) surfaces in comparison to more wettable (but nonporous) surfaces. Further, Maiti, Khanna, Sen, and Nigam (2004) in an experimental investigation on a trickle bed reactor applied the conceptual model of Khanna and Nigam (2002) to explain that porosity/nonporosity of the particles along with startup conditions of the bed play a major role in trickle bed operations. In another experimental study Maiti, Khanna, and Nigam (2005) proposed 'dual action' of pores in liquid spreading over porous substrates, whereby liquid movement is facilitated as well as restricted is presented based on spreading of micro-liter-sized liquid drops on substrates that have saturated (filled) pores.

In the present work, CFD model based on the volume of fluid (VOF) method is used to carry out 2D simulation of drop dynamics on porous flat surface. Surface tension and wall adhesion phenomenon are included in the computational model. The simulation scheme used has been validated with the work of Gunjal, Ranade and Chaudhari (2003).

The results of these simulations (shown in **Fig.1 (a), (b), (c), (d)** and Fig.2) are in agreement with the conceptual model of Khanna and Nigam (2002) i.e. liquid will spread more on less wettable (but porous) surfaces in comparison to more wettable (but nonporous) surfaces. The decrease in stabilization time (time after which the spreading and recoiling cycles are totally dampened) for a drop with increasing pore density of saturated porous flat solid (shown in **Fig.3**) confirms the restrictive liquid movement over saturated porous surface as expected by the theory of 'dual action' of pores [(Maiti, Khanna, and Nigam (2005)]

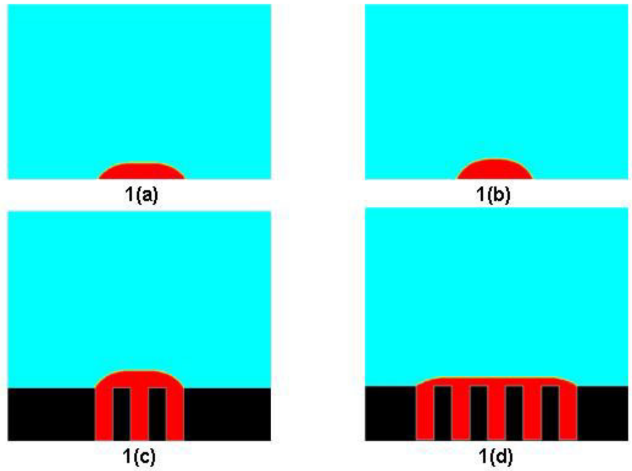

Fig. 1(a) shows 2.5 mm diameter water drop resting over a nonporous more wettable (contact angle 57^0). **1(b)** shows 2.5 mm diameter water drop resting over a nonporous less wettable (Contact angle 70^0). **(1c)** and **1(d)** show increase in wetting efficiency for a less wettable porous solid with increasing pore density.

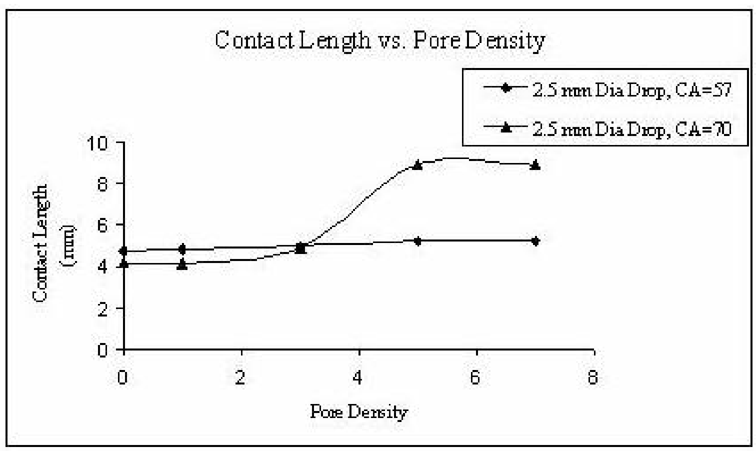

Fig.2. Variation on liquid contact length with increasing pore density for 2.5 mm diameter water drop over less wettable (contact angle 70^0) and more wettable (contact angle 57^0) porous flat solid.

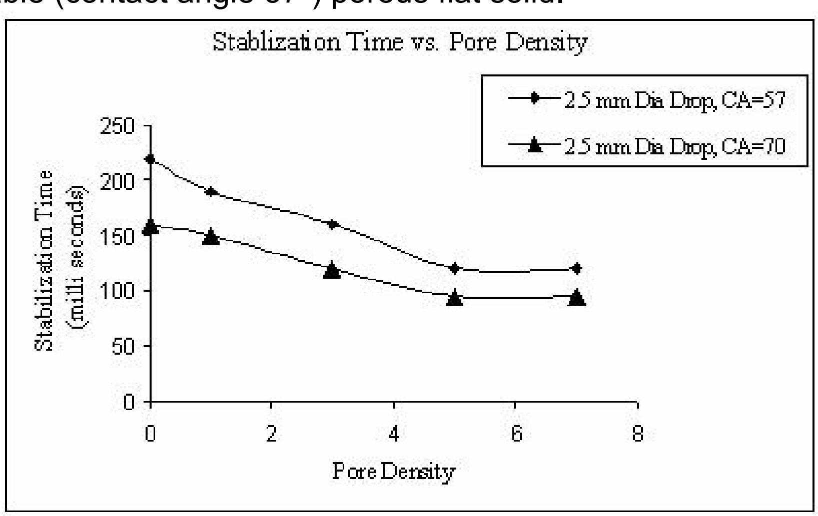

Fig.3. Stabilization time profiles with increasing pore density for 2.5 mm diameter water drop.

References

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