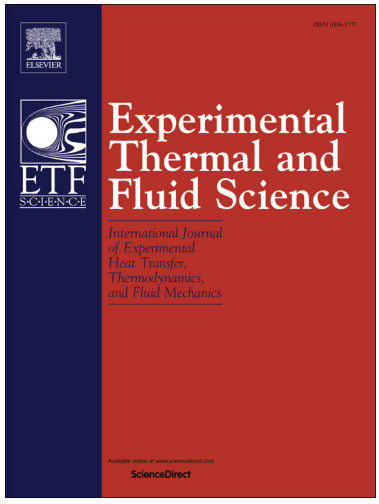

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The thermal conductivity-dependant drag reduction mechanism of water droplets controlled by graphene/silicone rubber composites

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Abstract: Graphene/silicone rubber (GP/SR) composites were tested for their ability to achieve thermal conductivity-dependent drag reduction, inspired by the phenomenon of a 9°C temperature difference between dolphin skin and the boundary layer of the surrounding water, typically attributed to a drag reduction mechanism termed boundary heating. To verify and reproduce this mechanism, the composites were prepared to mimic the elasticity and thermal conductivity of dolphin skin by using graphenes (GPs) as a thermally conductive filler at weight fractions of 0.18 wt%, 0.36 wt%, and 0.72 wt% and pristine silicone rubber (SR) as the matrix. Water droplets were used instead of layers of fluid in the experiments, and were allowed to slide on the various GP/SR composites with different contents, and on pure SR, at different temperatures. Tests of the thermal conductivity of the composites and water droplet velocity showed that the thermal conductivity of the three GP/SR composites increased by 20%, 40%, and 50% compared with SR, a graphene content of 0.36 wt% was established as the threshold value at which the thermal conductivity coefficient hardly changed when the graphene content exceeded 0.36 wt%. The velocity trends of water droplets on the GP/SR composites were totally different from the trend for the SR due to differences in thermal conductivity. A balanced critical heating temperature of 55°C was identified, at which the water droplets rolled most easily and as fast as possible. The highest velocity on the GP/SR was 18.6×10^{-4}m/s, almost 2.2 times faster than on the SR. The drag reduction mechanism of GP/SR composites is due to the thermal conductivity and balanced critical heating temperature of 55°C; in this condition, the dynamic viscosity of water droplets is reduced and the contact area is not greatly enlarged, thus reducing the drag, which resulted in drag reduction. The results confirm the drag reduction mechanism of boundary heating in dolphin skin, and indicate potential applications of these GP/SR composites in fluid machinery.

Key words: graphene; composites; thermal conductivity; droplet velocity; drag reduction