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Evaluation of the oil/water selective plugging performance of nano-polymer microspheres in fractured carbonate reservoirs

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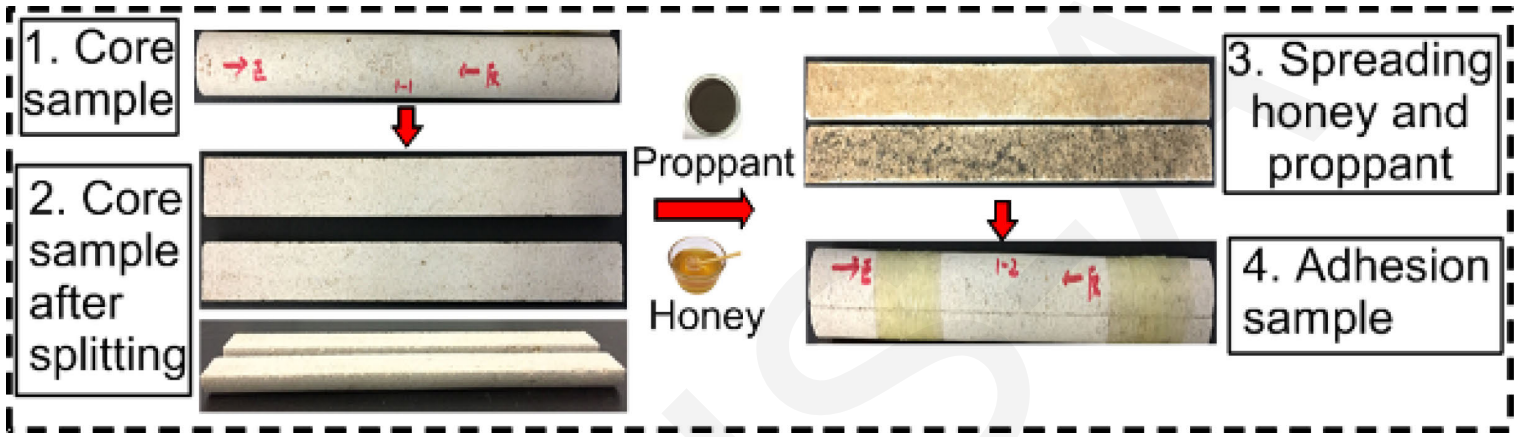
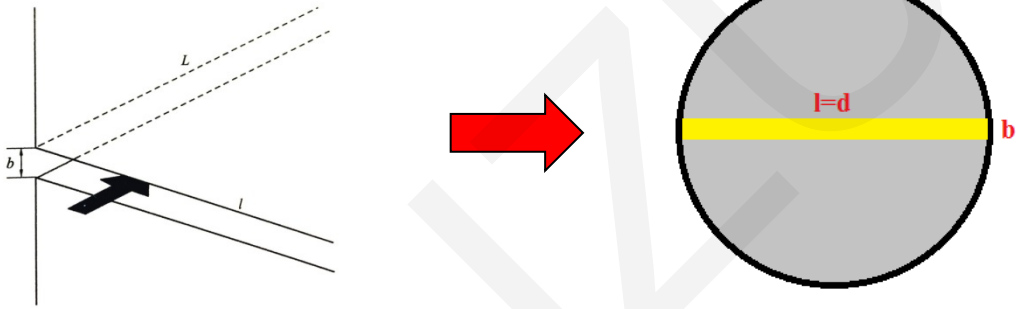
Highlights 1: Making fracture type model and equivalent slit width calculation

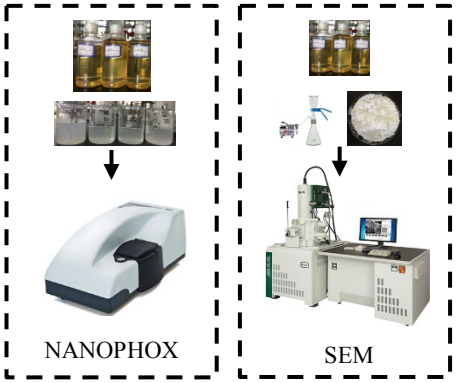




$$b = \sqrt[3]{3\pi d\left(K_t - K_m\right)},$$

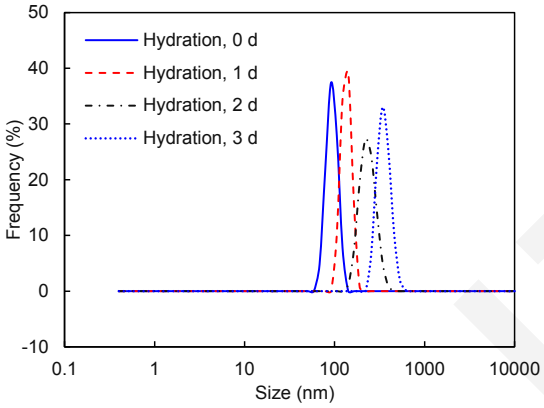
where b is the equivalent fracture width, cm; d is the core diameter, cm; K_t is the measured permeability of the fracture matrix system, cm^2; K_m is the measured permeability of the matrix, cm^2.

Highlights 2: Microscopic evaluation of the hydration expansion characteristics of the microspheres

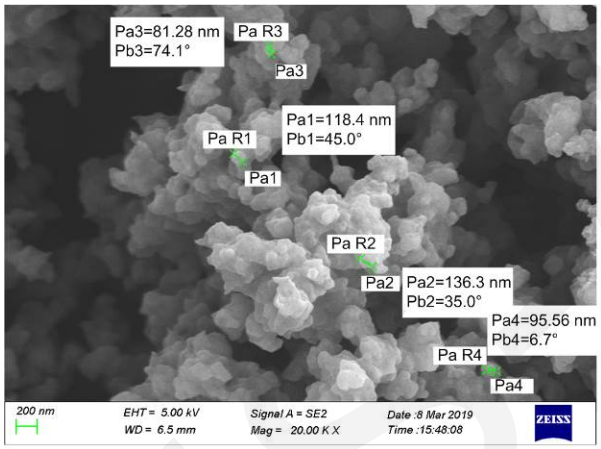


Hydration Particle Size Test

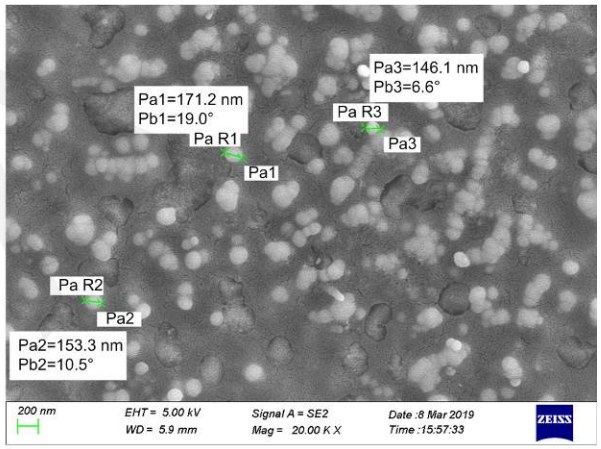
Dry Microspheres Microstructure



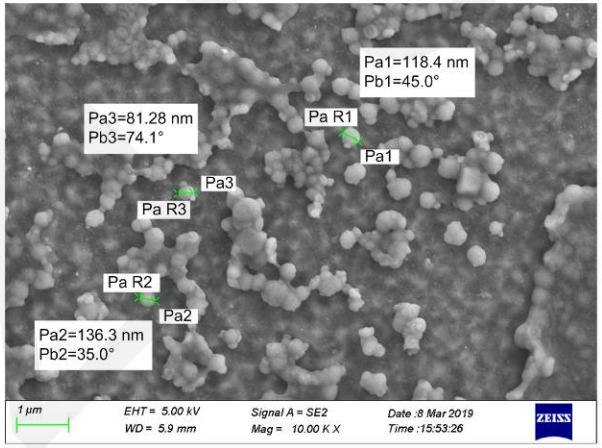
Particle sizes of microspheres after 0–3 d of hydration



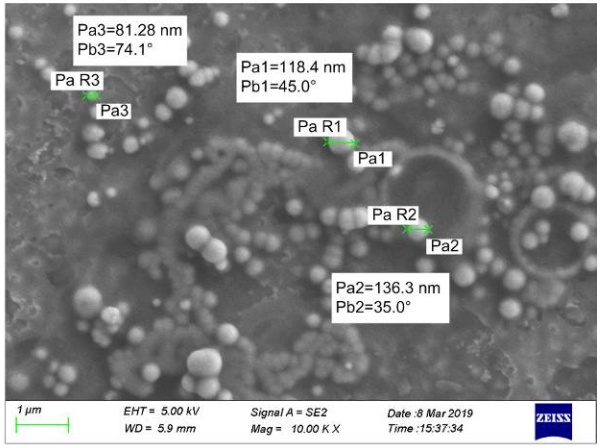
(a)



(b)



(c)

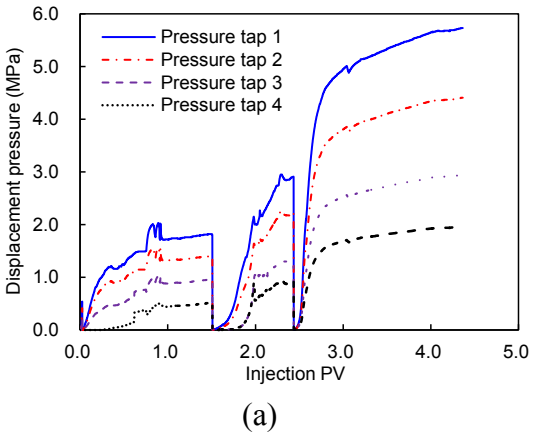


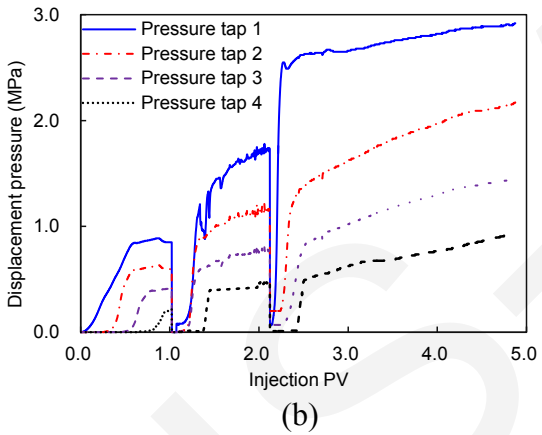
(d)

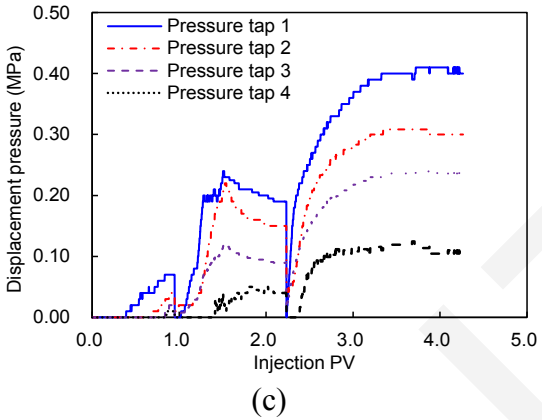
SEM images showing the morphology and size of polymer microspheres after different hydration times

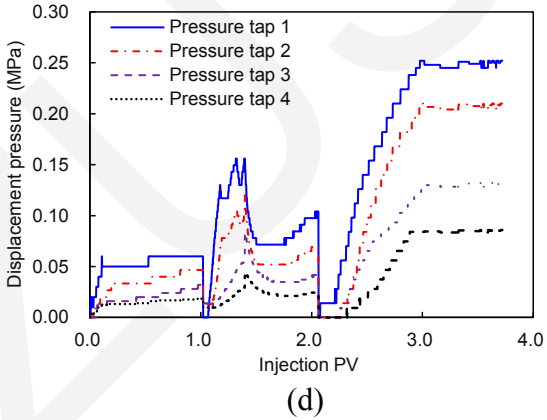
(a) Microsphere hydration for 0 d (scale: 200 nm); (b) Microsphere hydration for 1 d (scale: 200 nm); (c) Microsphere hydration for 2 d (scale: 1 μm); (d) Microsphere hydration for 3 d (scale: 1 μm)

Highlights 3: PM deep plugging performance evaluation



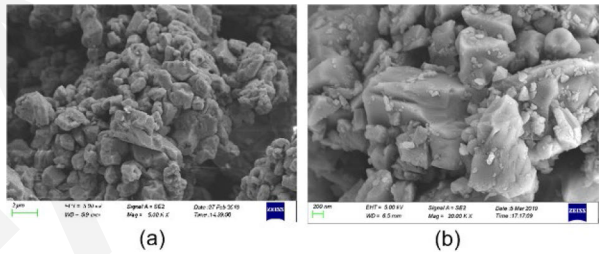






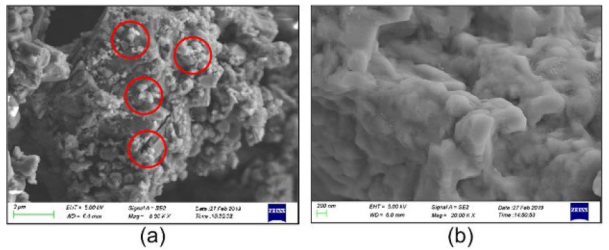
Plugging curves of the matrix and fractured carbonate cores

(a) 1.70 mD matrix core; (b) 3.60 mD matrix core; (c) 43.96 mD fractured core; (d) 50.01 mD fractured core



SEM images of clean carbonate rock powder

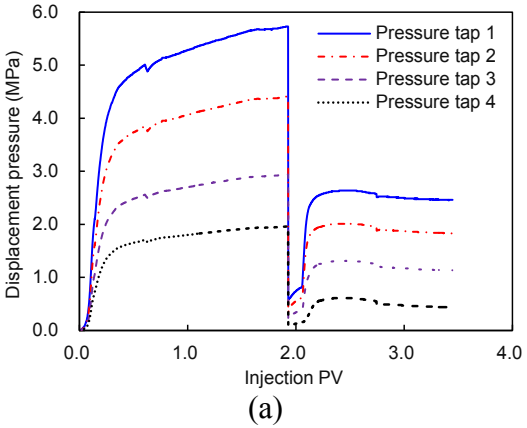
(a) Scale bar of 2 μm; (b) Scale bar of 200 nm

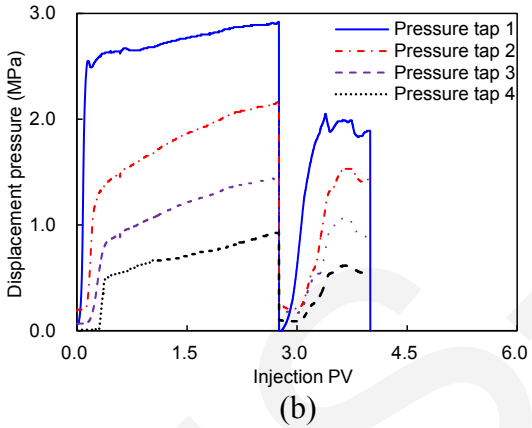


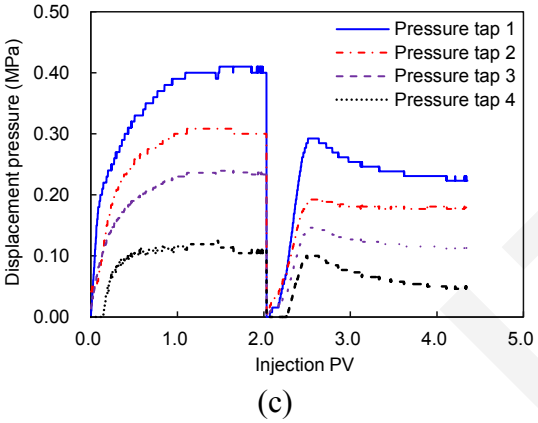
SEM images of carbonate rock powder after the plugging experiment

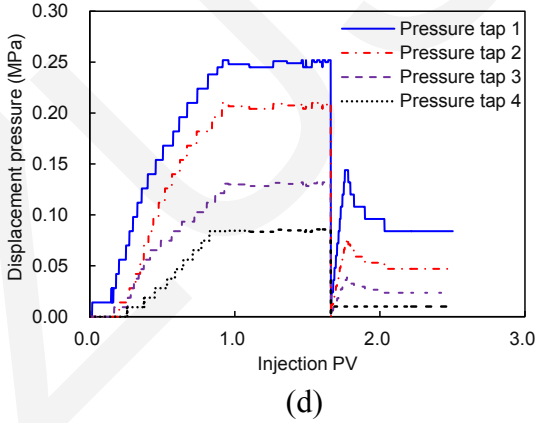
(a) Scale bar of 2 μm; (b) Scale bar of 200 nm

Highlights 4: PM oil/water selective plugging evaluation



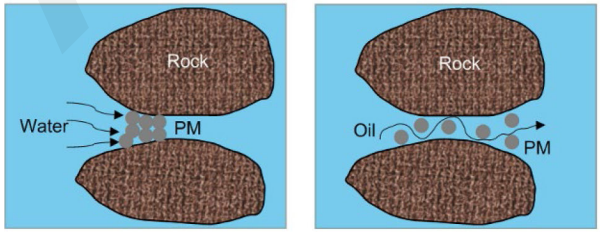






Curves of experimental results for oil/water selective plugging of matrix and fractured carbonate core

(a) 1.70 mD matrix core; (b) 3.60 mD matrix core; (c) 43.96 mD fractured core; (d) 50.01 mD fractured core



Schematic diagram of the oil/water selective plugging mechanism

Conclusions

- PM had good dispersion and swelling ability in simulated formation water. The swelling rate reached more than 300% in 3 d. PM had a perfect deep plugging effect in both matrix core and fractured core. The residual resistance coefficient of matrix and fractured core after plugging reached between 3.29 and 5.88, and the plugging rate was between 69.58% and 83.01%. The higher the residual resistance coefficient, the higher the plugging rate. PM has a good selective plugging effect on oil/water. The oil/water selection coefficient Rw/o was less than 1.0 and close to 0, mainly because of the different mechanisms of oil/water and PM. SEM imaging results showed that the plugging mechanism of PM in the throat and fractures was manifested mainly in three aspects: adsorptive retention, mechanical trapping, and agglomeration plugging. The mechanism was further verified by EDS elemental analysis technology.