IONIC EFFECTS ON SILICA PRECIPITATION IN ACIDIC SOLUTIONS

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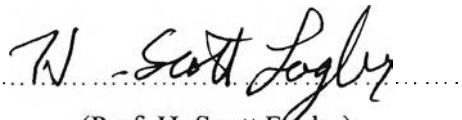

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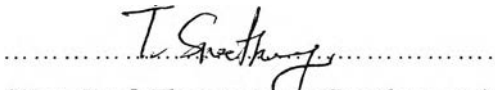

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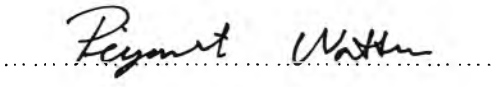

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ABSTRACT

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In the upstream petroleum industry, silica precipitation during the matrix acidization of sandstone reservoirs has become a serious problem that potentially causes significant losses in the permeability of reservoirs and oil productivity. This research has aimed to study the influence of salts and ionic strength on the precipitation behavior of silica in highly acidic circumstances. A number of salts were used to investigate the growth of silica particles and the aggregation phenomena. The ICP/MS and Light Scattering results indicated that the presence of salts can accelerate silica particle growth and that the different salts promote particle growth rate in the following order: $AlCl_3$ > $CaCl_2$ > $MgCl_2$ > NaCl > CsCl for chloride salts and NaI > NaBr > NaCl ~ $NaNO_3$ for sodium salts. The silica particles undergo exponential growth with time, and the evolution of particle sizes can be well-simulated by using the reaction-limited aggregation (RLA) model under the framework of a geometric population balance equations. From UV-Vis experiments, it was found that the monosilicic acid disappears very rapidly from the solution and the disappearance rate is third order with respect to the molar concentration of monosilicic acid. It was also found that disappearance rate constants, particle growth rate constants, and collision efficiency increase exponentially as a function of ionic strength.

บทคัดย่อ

พัฒนพงษ์ วงษ์ทหาร: อิทธิพลเชิงไอออนที่มีผลต่อการตกตะกอนของซิลิกาในสารละลายกรด (Ionic Effect on Silica Precipitation in Acidic Solutions) อาจารย์ที่ปรึกษา: ศาสตราจารย์ ดร.เอช สก๊อตต ฟอกเลอร์ และ ผู้ช่วยศาสตราจารย์ ดร.ปมทอง มาลากุล ณ อยุธยา 50 หน้า

ในอุตสาหกรรมปิโตรเลียมขั้นต้นน้ำ การตกตะกอนของซิลิกาในระหว่างกระบวนการแมทริกซ์แอซิไดเซชั่น (Matrix Acidization) ของแหล่งน้ำมันดิบหินทราย กลายเป็นปัญหาสำคัญ ซึ่งก่อให้เกิดความสูญเสียในเชิงของความสามารถในการซึมผ่านของน้ำมันดิบ และอัตราการผลิตน้ำมัน งานวิจัยนี้มุ่งศึกษาอิทธิพลของเกลือและกำลังเชิงไอออน ที่มีต่อพฤติกรรมการตกตะกอนของซิลิกาในสภาวะกรดอย่างรุนแรง เกลือหลายชนิดถูกนำมาใช้เพื่อศึกษาการเติบโตของอนุภาคและการรวมตัวกันของอนุภาคซิลิกา ผลการทดลองจากเทคนิคเอซีพี/เอ็มเอส และเทคนิคการกระจายตัวของแสงบ่งชี้ว่า เกลือสามารถเร่งการเติบโตของอนุภาคซิลิกา และ เกลือชนิดต่างๆ ช่วยกระตุ้นอัตราการเติบโตของอนุภาคซิลิกา ตามลำดับ

อะลูมิเนียมคลอไรด์ > แคลเซียมคลอไรด์ > แมกนีเซียมคลอไรด์ > โซเดียมคลอไรด์ > ซีเซียมคลอไรด์,

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อนุภาคซิลิกามีการเติบโตแบบเอ็กซโพเนนเชียลตามเวลา และการเติบโตของขนาดอนุภาคสามารถถูกอธิบายในเชิงการคำนวณได้โดยใช้แบบจำลองการรวมตัวกันแบบปฏิกิริยาเป็นตัวกำหนด ร่วมกับสมการการสมดุลประชากรเชิงเรขาคณิต จากการทดลองยูวี-วิส พบว่า กรดโมโนซิลิซิกหายไปจากสารละลายอย่างรวดเร็ว และอัตราการหายไปเป็นแบบอันดับสามต่อความเข้มข้นเชิงโมลของกรดโมโนซิลิซิก นอกจากผลดังกล่าว ยังพบอีกว่า ค่าคงที่การสูญหาย ค่าคงที่การเติบโตของอนุภาค และประสิทธิภาพการชน เพิ่มขึ้นแบบเอ็กซโพเนนเชียลตามฟังก์ชั่นของกำลังเชิงไอออน

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