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**Exploring the Dominant Factors of Chemical Adsorption in Enhanced Oil Recovery: An Analytical Investigation**

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1. Appendix
   1. Design Expert Data

The following tables show the generated runs of the design expert software in the first six columns, such that these runs were performed, and the responses (Ad and Rrf) were calculated experimentally then reentered in the software in order to generate the model.

**Table 6:** Experimental runs for polymer in Sandstone formation

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Run | A:Poly | B:Nano | C:Salinity | D:Temp | E:Flow Rate | Ads | Rrf |
|  | ppm | ppm | wt% | C | ml/min | mg/g |  |
| 1 | 635 | 793.5 | 5.1 | 25 | 4 | 0.4 | 15 |
| 2 | 1050 | 1857.5 | 2.55 | 70 | 6 | 0.7 | 28 |
| 3 | 890 | 765 | 5 | 25 | 2 | 0.42 | 16 |
| 4 | 500 | 613 | 0 | 50 | 2 | 0.3 | 10 |
| 5 | 1475 | 100 | 0 | 25 | 2 | 0.79 | 32 |
| 6 | 500 | 613 | 0 | 50 | 2 | 0.28 | 9 |
| 7 | 1155 | 1667.5 | 10 | 25 | 4 | 0.93 | 38 |
| 8 | 500 | 1500 | 3 | 50 | 4 | 0.41 | 14 |
| 9 | 500 | 100 | 0 | 70 | 2 | 0.26 | 6 |
| 10 | 1500 | 1829 | 4.75 | 50 | 6 | 1 | 41 |
| 11 | 1380 | 100 | 10 | 70 | 2 | 0.52 | 20 |
| 12 | 500 | 1000 | 0 | 70 | 2 | 0.35 | 12 |
| 13 | 1500 | 2000 | 2 | 25 | 4 | 1.04 | 43 |
| 14 | 1500 | 1000 | 4.75 | 50 | 6 | 0.86 | 35 |
| 15 | 1475 | 979.905 | 10 | 25 | 4 | 0.95 | 39 |
| 16 | 1500 | 861.475 | 7.3 | 25 | 6 | 1.02 | 42 |
| 17 | 1050 | 100 | 6.35 | 50 | 4 | 0.635 | 25 |
| 18 | 500 | 100 | 1 | 70 | 4 | 0.33 | 11 |
| 19 | 1050 | 100 | 6.35 | 50 | 4 | 0.6 | 23.5 |
| 20 | 900 | 1500 | 2 | 50 | 2 | 0.54 | 21 |
| 21 | 1100 | 800 | 9 | 50 | 4 | 1.07 | 44 |
| 22 | 500 | 100 | 5 | 70 | 6 | 0.2 | 6 |
| 23 | 600 | 700 | 2 | 50 | 2 | 0.38 | 13 |
| 24 | 1100 | 1300 | 5.5 | 25 | 2 | 0.66 | 26 |

**Table 7:** Experimental runs for polymer in Limestone formation

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Run | A:Poly | B:Nano | C:Salinity | D:Temp | E:Flow Rate | Ads | Rrf |
|  | ppm | ppm | wt% | C | ml/min | mg/g |  |
| 1 | 500 | 200 | 7 | 50 | 2 | 0.28 | 13 |
| 2 | 1500 | 1800 | 4 | 25 | 2 | 1.32 | 69 |
| 3 | 500 | 100 | 2 | 70 | 2 | 0.21 | 10 |
| 4 | 1500 | 2000 | 2 | 25 | 6 | 1.38 | 72 |
| 5 | 1400 | 1500 | 8 | 70 | 2 | 1.28 | 67 |
| 6 | 1450 | 1800 | 7 | 50 | 6 | 1.21 | 63 |
| 7 | 1200 | 1100 | 9 | 50 | 4 | 1.13 | 59 |
| 8 | 700 | 800 | 9 | 25 | 4 | 0.44 | 21 |
| 9 | 1100 | 1700 | 10 | 25 | 2 | 0.99 | 52 |
| 10 | 1500 | 200 | 9 | 25 | 2 | 0.85 | 44 |
| 11 | 1050 | 400 | 0 | 50 | 2 | 0.62 | 31 |
| 12 | 1060 | 200 | 2 | 50 | 4 | 0.73 | 38 |
| 13 | 1060 | 1800 | 0 | 50 | 2 | 0.79 | 41 |
| 14 | 1400 | 300 | 8 | 70 | 4 | 0.54 | 26 |
| 15 | 1500 | 1050 | 10 | 50 | 6 | 0.91 | 47 |
| 16 | 900 | 700 | 8 | 25 | 2 | 0.48 | 23 |
| 17 | 1450 | 900 | 9 | 25 | 4 | 1.09 | 57 |
| 18 | 600 | 1350 | 10 | 50 | 2 | 0.41 | 19 |
| 19 | 1500 | 1900 | 8 | 50 | 6 | 1.15 | 60 |
| 20 | 500 | 1100 | 6 | 70 | 2 | 0.35 | 16 |
| 21 | 500 | 400 | 9 | 70 | 4 | 0.32 | 15 |
| 22 | 500 | 100 | 10 | 70 | 2 | 0.27 | 12 |
| 23 | 1500 | 2000 | 2 | 25 | 6 | 1.35 | 70 |
| 24 | 500 | 300 | 8 | 70 | 2 | 0.3 | 14 |

**Table 8:** Experimental runs for surfactant in Sandstone formation

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Run | A:surf | B:Nano | C:Salinity | D:Temp | E:Flow Rate | Ads | Rrf |
|  | ppm | ppm | wt% | C | ml/min | mg/g |  |
| 1 | 2000 | 650 | 0 | 50 | 2 | 0.21 | 3.5 |
| 2 | 2000 | 100 | 2 | 25 | 2 | 0.17 | 3 |
| 3 | 2000 | 100 | 0 | 25 | 2 | 0.11 | 2 |
| 4 | 5000 | 2000 | 10 | 70 | 6 | 1.15 | 14 |
| 5 | 5000 | 2000 | 9 | 70 | 4 | 1.12 | 14 |
| 6 | 5000 | 1100 | 10 | 70 | 2 | 1.09 | 13.5 |
| 7 | 5000 | 2000 | 10 | 25 | 6 | 1.04 | 13 |
| 8 | 4900 | 1800 | 9 | 50 | 2 | 0.98 | 12.5 |
| 9 | 2500 | 700 | 5 | 70 | 2 | 0.34 | 5 |
| 10 | 4800 | 1700 | 6 | 50 | 6 | 0.88 | 12 |
| 11 | 3650 | 100 | 6 | 50 | 2 | 0.39 | 6 |
| 12 | 5000 | 100 | 4 | 50 | 4 | 0.43 | 6 |
| 13 | 3800 | 1050 | 5 | 50 | 2 | 0.58 | 8 |
| 14 | 3500 | 100 | 10 | 70 | 2 | 0.56 | 8 |
| 15 | 3680 | 1800 | 3 | 25 | 2 | 0.5 | 7.5 |
| 16 | 3500 | 1500 | 0 | 70 | 4 | 0.79 | 11 |
| 17 | 4000 | 1000 | 4 | 70 | 4 | 0.84 | 11.5 |
| 18 | 4700 | 1500 | 8 | 50 | 4 | 0.86 | 11.5 |
| 19 | 4000 | 500 | 2 | 25 | 6 | 0.37 | 5.5 |
| 20 | 2600 | 800 | 5 | 70 | 4 | 0.33 | 5 |
| 21 | 2300 | 1350 | 4 | 50 | 2 | 0.32 | 4.5 |
| 22 | 3000 | 1000 | 0 | 25 | 2 | 0.3 | 4.5 |
| 23 | 2000 | 200 | 1 | 25 | 4 | 0.27 | 4 |
| 24 | 2000 | 650 | 0 | 50 | 2 | 0.22 | 3.4 |

**Table 9:** Experimental runs for surfactant in Limestone formation

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Run | A:Surf | B:Nano | C:Salinity | D:Temp | E:Flow Rate | Ads | Rrf |
|  | ppm | ppm | wt% | C | ml/min | mg/g |  |
| 1 | 2000 | 300 | 2 | 50 | 2 | 0.26 | 8 |
| 2 | 2000 | 100 | 0 | 50 | 6 | 0.29 | 9 |
| 3 | 2000 | 100 | 0 | 25 | 6 | 0.2 | 6 |
| 4 | 5000 | 2000 | 10 | 25 | 6 | 1.48 | 38 |
| 5 | 5000 | 2000 | 10 | 25 | 6 | 1.46 | 38.1 |
| 6 | 4500 | 1500 | 7.3 | 25 | 6 | 1.4 | 37 |
| 7 | 2200 | 100 | 5 | 50 | 4 | 0.64 | 19 |
| 8 | 2000 | 2000 | 9.9 | 70 | 6 | 1.36 | 37 |
| 9 | 2700 | 200 | 5 | 25 | 4 | 0.79 | 24 |
| 10 | 3500 | 1829 | 6 | 50 | 6 | 1.32 | 36 |
| 11 | 2500 | 900 | 5 | 70 | 2 | 0.92 | 28 |
| 12 | 3000 | 1800 | 7 | 50 | 6 | 1.29 | 35 |
| 13 | 4000 | 1800 | 4 | 25 | 4 | 1.1 | 30 |
| 14 | 2500 | 1200 | 9 | 70 | 4 | 1.21 | 33 |
| 15 | 3500 | 1250 | 5 | 50 | 6 | 1.16 | 32 |
| 16 | 3900 | 1500 | 10 | 70 | 4 | 1.19 | 34 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 17 | 3800 | 1100 | 0 | 70 | 4 | 1.14 | 31 |
| 18 | 3400 | 1800 | 10 | 50 | 4 | 1.25 | 34 |
| 19 | 4500 | 1500 | 7 | 70 | 6 | 0.99 | 30 |
| 20 | 4700 | 1000 | 8 | 70 | 4 | 0.88 | 26 |
| 21 | 2500 | 900 | 4 | 25 | 4 | 0.71 | 21 |
| 22 | 2300 | 300 | 7 | 70 | 2 | 0.58 | 17 |
| 23 | 2000 | 100 | 1 | 70 | 4 | 0.49 | 15 |
| 24 | 2000 | 300 | 0 | 50 | 6 | 0.41 | 12 |

1.2. Model Equations

|  |  |  |
| --- | --- | --- |
| *Polymer* | *Ad1* | 1.043 + 0.326 A + 0.199 B + 0.144 C + 0.1803 D + 0.096 E + 0.071 AB + 0.225 AC - 0.187 AD + 0.03 AE + 0.235 BC + 0.018 BD + 0.093 BE + 0.419 CD + 0.27 CE - 0.005 DE - 0.292 A² - 0.252 B² - 0.166 C² + 0.127 D² - 0.289 E² |
| *Rrf1* | 40.848 + 14.134 A + 8.917 B + 7.371 C + 8.109 D + 3.208 E + 3.809 AB + 9.277 AC - 7.92 AD + 3.439 AE + 10.98 BC + 3.486 BD + 0.945 BE + 19.579 CD + 9.597 CE - 0.145 DE - 11.963 A² - 8.713 B² - 5.307 C² + 6.376 D² - 12.524 E² |
| *Surfactant* | *Ad2* | 0.573 + 0.19 A + 0.116 B + 0.097 C + 0.062 D + 0.046 E + 0.104 AB - 0.026 AC + 0.303 AD + 0.022 AE + 0.061 BC - 0.107 BD - 0.029 BE - 0.17 CD - 0.037 CE - 0.037 DE - 0.098 A² - 0.072 B² + 0.093 C² + 0.029 D² + 0.0245 E² |
| *Rrf2* | 8.161 + 2.874 A + 1.089 B + 0.642 C + 0.759 D + 0.519 E + 1.803 AB + 0.597 AC + 3.469 AD + 0.804 AE - 0.011 BC - 1.466 BD - 0.497 BE - 2.135 CD - 0.924 CE - 0.184 DE - 1.729 A² - 0.867 B² + 0.62 C² + 0.334 D² + 0.063 E² |
| \*Where *Ad1, Rrf1, Ad2, Rrf2* represent the amount of adsorption and residual resistance factor in polymer, and surfactant respectively. While A, B, C, D, E represent the polymer concentration, nano-Silica concentration, Salinity, Temperature, and flow rate respectively. | | |

**Table 10:** Generated Model Equations