

PHOTOCATALYTIC DEGRADATION OF
PHENOL IN A SIMULATED OIL FIELDS
PRODUCED WATER AND POTENTIAL
REUSE FOR AGRICULTURE PURPOSES

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We hereby declare that we have checked this thesis, and, in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Philosophy.

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Jumlah besar air sisa yang sering dikenali sebagai "air yang dihasilkan" biasanya terjana semasa pemprosesan pengeluaran minyak dan gas. Air yang dihasilkan ini lazimnya dianggap sebagai sisa toksik berisi padu tinggi, di mana ianya perlu dirawat dengan sewajarnya untuk memenuhi piawaian yang ditetapkan sebelum dibuang atau digunakan untuk tujuan lain. Rawatan air yang dihasilkan adalah sangat penting atas isu perundangan dan alam sekitar. Air yang dihasilkan menimbulkan masalah rawatan yang unik dan kompleks, merawat air yang dihasilkan medan minyak sebelum dilepaskan mungkin menjadi semakin sukar disebabkan oleh keterbatasan teknologi rawatan konvensional. Dalam kajian ini, penggunaan nanokomposit ZnO/Fe₂O₃ sebagai fotomangkin untuk penguraian bahan pencemar toksik dalam air yang dihasilkan medan minyak telah disiasat. Nanokomposit ZnO/Fe₂O₃ telah disediakan melalui kaedah sol-gel dan dicirikan oleh Analisis Pembelauan Sinar-X (XRD), Mikroskop Elektron Penghantaran (TEM), Mikroskop Elektron Pengimbasan Pelepasan Medan (FESEM), analisis fisisorpsi N₂, Spektrofotometer Ultraungu Tampak, dan Penganalisis Termogravimetrik (TGA). Aktiviti fotokatalitik nanokomposit ZnO/Fe₂O₃ telah diperiksa menggunakan degradasi fenol dalam medan minyak simulasi yang menghasilkan air di bawah cahaya matahari langsung. Kesan parameter seperti masa penyinaran, kepekatan fenol awal, pH dan dos ZnO/Fe₂O₃ ke atas degradasi fenol telah diperiksa dan dioptimumkan menggunakan metodologi permukaan tindak balas dan Reka Bentuk Box-Behnken. Kajian menunjukkan bahawa ketiga-tiga parameter mempunyai pengaruh yang ketara terhadap degradasi fenol dari medan minyak simulasi yang dihasilkan air. Walau bagaimanapun, analisis varians (ANOVA) menunjukkan bahawa kesan parameter pada peratusan fenol boleh disenaraikan sebagai masa penyinaran > kepekatan fenol awal, dos ZnO/Fe₂O₃ > pH. Interaksi antara parameter diperhatikan mempunyai kesan yang besar terhadap degradasi fenol. Pada keadaan optimum 176 min, 3 mg/L, 4.34, dan 4.11 mg/L untuk masa penyinaran, kepekatan fenol awal, pH, dan dos ZnO/Fe₂O₃, 92.56% fenol adalah degradasi daripada air terhasil yang dimodelkan. Nilai ramalan 92.56% yang diperoleh daripada model RSM adalah konsisten dengan nilai yang disahkan 93.29% dengan reja 0.73%.

ABSTRACT

Large volume of wastewater often known as “produced water” are usually generated during the processing of oil and gas production. This produced water is commonly regarded as a high-volume toxic waste, which needed to be appropriately treated to meet the stipulated standard before being discharged or used for other purposes. The treatment of produced water is very important due to legislation and environmental concerns. Produced water poses a unique and complex treatment problem, treating oil field produced water prior to discharge may become increasingly difficult due to the limitations of the conventional treatment technologies. In this study, the use of ZnO/Fe₂O₃ nanocomposite as photocatalysts for the degradation of toxic pollutants in oil field produced water has been investigated. ZnO/Fe₂O₃ nanocomposite was prepared by sol-gel method and characterized by X-ray diffraction analysis (XRD), Transmission electron microscope (TEM), Field Emission, Scanning Electron Microscope (FESEM), N₂ physisorption analysis, Ultra-Violet-Visible Spectroscopy and Thermogravimetric Analyzer (TGA). The photocatalytic activity of the ZnO/Fe₂O₃ nanocomposite was examined using the degradation of the phenol in the simulated oil field produced water under direct sunlight. The effects of parameters such as the irradiation time, initial phenol concentration, pH and ZnO/Fe₂O₃ dosage on the phenol degradation were examined and optimized using response surface methodology and Box-Behnken Design. The study shows that all the three parameters had significant influence on the phenol degradation from the simulated oil field produced water. However, the analysis of variance (ANOVA) shows that the effects of the parameters on the percentage phenol can be ranked as irradiation time > initial phenol concentration, ZnO/Fe₂O₃ dosage > pH. The interaction between the parameters were observed to have substantial effect phenol degradation. At the optimum conditions of 176 min, 3 mg/L, 4.34, and 4.11 mg/L for irradiation time, initial phenol concentration, pH and ZnO/Fe₂O₃ dosage, 92.56% phenol was degradation from the modelled produced water. The predicted value of 92.56% obtained from the RSM model is consistent with the validated values of 93.29% with a residual of 0.73%.

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