OPTIMIZATION OF BIODIESEL PRODUCTION USING HYBRID ARTIFICIAL NEURAL NETWORK – GENETIC ALGORITHM (ANN-GA) MODEL

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ABSTRACT

Response surface methodology (RSM) is the most preferable method for biodiesel production optimization. In recent years, hybrid model of artificial neural network-genetic algorithm (ANN-GA) had come up as a more promising method for empirical modeling and optimization even with limited training data. In this study, the yield of ester was modeled and optimized as a function of four independent variables (methanol to oil ratio, catalyst loading, reaction time and reaction temperature) using ANN-GA model and compared to RSM model. In developing ANN model, performance of ANN is heavily influenced by its network structure; therefore optimum ANN structure had to be determined first using mean square error (MSE) approach. ANN with 4-15-1 structure exhibited lowest MSE among others. This ANN structure was used for modeling the biodiesel production and the result was compared with RSM from previous study. Based on results, the ANN model shown better performance than RSM due to lower MSE, 18.32 and higher coefficient of determination, $R^2$ value, 0.8929. Variable analysis also been conducted to study the effect of variables towards ester yield using relative importance and 3D response surface plot. Methanol to oil ratio found to be slightly more significant than others variables. Process optimization was conducted using hybrid ANN-GA model. The optimum operating condition predicted was 90.45% of ester yield with 4.03% error under 22.75 methanol oil ratio, catalyst loading of 1.88 wt.%, reaction time of 113 minutes, and reaction temperature of 182°C.
ABSTRAK

Response Surface Methodology (RSM) adalah kaedah yang paling digemari dalam pengoptimuman penghasilan biodiesel. Tahun kebelakangan ini, model hibrid Artificial Neural Network-Genetic Algorithm (ANN GA) telah tampil sebagai kaedah yang lebih berkesan untuk permodalan dan pengoptimuman walaupun dengan data latihan yang terhad. Dalam kajian ini, hasil ester telah dimodelkan dan dioptimumkan sebagai fungsi empat pembolehubah bebas (nisbah methanol minyak, berat mangkin, masa tindak balas dan suhu tindak balas) menggunakan ANN-GA model dan keputusannya dibandingkan dengan model RSM. Dalam pembangunan ANN, prestasi ANN banyak dipengaruhi oleh struktur rangkaian; oleh itu, struktur ANN yang optimum harus ditentukan terlebih dahulu menggunakan pendekatan Mean Square Error (MSE). ANN dengan struktur 4-15-1 mempamerkan MSE terendah diantara yang lain. Struktur ANN ini digunakan untuk memodelkan pengeluaran biodiesel dan keputusannya telah dibandingkan dengan RSM daripada kajian sebelumnya. Model ANN menunjukkan prestasi yang lebih baik daripada RSM kerana MSE yang lebih rendah, 18.32 dan Coefficient of Determination, $R^2$ yang lebih tinggi, 0.8929. Analisis Pembolehubah juga telah dijalankan untuk mengkaji kesan pembolehubah ke arah hasil ester menggunakan Relative Importance dan 3D Response Surface Plot. Nisbah metanol kepada minyak didapati lebih penting daripada pembolehubah yang lain. Pengoptimuman proses telah dijalankan menggunakan model hibrid ANN-GA. Keadaan operasi yang optimum diramalkan adalah 90.45% hasil ester dengan ralat 4.03% dibawah keadaan nisbah metanol minyak, 22.75, berat mangkin, 1.88%, masa tindak balas sebanyak 113 minit, dan suhu tindak balas, 182 ^\circ C.
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