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OIL REMOVAL FROM USED CUTTING FLUID BY CONTINUOUS ADSORPTION ON MODIFIED CHITIN-CHITOSAN

Mr. Kowit Piyamongkala

A Dissertation Submitted in Partial Fulfillment of the Requirements

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Department of Chemical Technology

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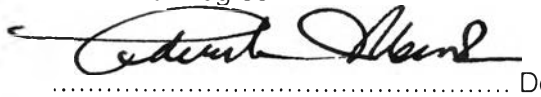

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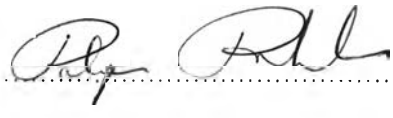

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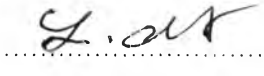

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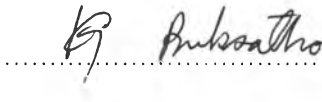

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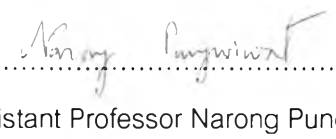

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โกวิทย์ ปิยะมังคลา : การขจัดน้ำมันจากของไหลตัดชิ้นงานที่ใช้แล้วโดยการดูดซับแบบต่อเนื่องบนไคติน-ไคโตซานดัดแปร. (OIL REMOVAL FROM USED CUTTING FLUID BY CONTINUOUS ADSORPTION ON MODIFIED CHITIN-CHITOSAN) อ. ที่ปรึกษา: ผศ. ดร. สงบทิพย์ พงศ์สถาบดี, อ. ที่ปรึกษาร่วม: รศ. ดร. เลอสรวง เมฆสุต, 259 หน้า.

วัตถุประสงค์ของงานวิจัยนี้ เพื่อศึกษาการขจัดน้ำมันหล่อเย็นโดยการดูดซับบนตัวดูดซับไคโตซานและไคโตซานดัดแปร ตัวดูดซับที่ใช้ในการศึกษานี้ได้แก่ ไคโตซาน ไคโตซานผสมพอลีไวนิลแอลกอฮอล์ เบนโซอิลไคโตซาน คอรล์เตอร์อมิเนตไคโตซาน ไคโตซานผสมสารลดแรงตึงผิวประจุลบ ไคโตซานผสมสารลดแรงตึงผิวประจุบวก ไคโตซานผสมสารลดแรงตึงผิวไม่มีประจุ ไคโตซานผสมพอลีไวนิลแอลกอฮอล์ผสมสารลดแรงตึงผิวประจุลบ ไคโตซานผสมพอลีไวนิลแอลกอฮอล์ผสมสารลดแรงตึงผิวประจุบวกและไคโตซานผสมพอลีไวนิลแอลกอฮอล์ผสมสารลดแรงตึงผิวไม่มีประจุ ไคโตซานผสมสารลดแรงตึงผิวประจุลบ มีความสามารถในการดูดซับน้ำมันหล่อเย็นได้ดีที่สุด ที่ความเป็นกรด-เบส 3 ปริมาณ 2516 มิลลิกรัมต่อกรัม การเพิ่มความเป็นกรด-เบสจาก 7 ถึง 11 พบว่าความสามารถในการดูดซับน้ำมันหล่อเย็นลดลงจาก 747 ถึง 309 มิลลิกรัมต่อกรัม การดูดซับจะมีค่าสูงขึ้นเมื่อมีการเติมเกลือโซเดียมคลอไรด์หรือแคลเซียมคลอไรด์ ไคโตซานผสมสารลดแรงตึงผิวประจุลบ ดูดซับน้ำมันหล่อเย็นได้เนื่องจากแรงดึงดูดความไม่ชอบน้ำ การดูดซับน้ำมันหล่อเย็นบนตัวดูดซับสนับสนุนโดยผลการวิเคราะห์ของ มุมสัมผัส ภาพถ่ายจากกล้องจุลทรรศน์อิเล็กตรอนแบบส่องกราด อินฟราเรดสเปกตรัมจากฟูริเออร์ทรานฟอร์ม ปริมาณของธาตุคาร์บอน ไฮโดรเจน ไนโตเจนและความร้อนของการเผาไหม้ แบบจำลองแลงเมียร์ ฟรุนดิชและบีอีทีนำมาใช้ในการศึกษาไอโซเทอมของการดูดซับ จลนพลศาสตร์ของการดูดซับสอดคล้องกับปฏิกิริยาอันดับสอง การดูดซับน้ำมันหล่อเย็นถูกควบคุมโดยการแพร่ อัตราเร็วของการดูดซับเพิ่มขึ้นเมื่ออุณหภูมิเพิ่มสูงขึ้น การดูดซับน้ำมันหล่อเย็นเป็นปฏิกิริยาดูดความร้อน แบบจำลอง BDST นำมาใช้ในการทำนายการดูดซับในกรณีที่มีการเปลี่ยนแปลงอัตราการไหล

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KOWIT PIYAMONGKALA: OIL REMOVAL FROM USED CUTTING FLUID BY CONTINUOUS ADSORPTION ON MODIFIED CHITIN-CHITOSAN. THESIS ADVISOR: ASST. PROF. SANGOBTIP PONGSTABODEE, Ph.D., THESIS COADVISOR, ASSOC. PROF. LURSUANG MEKASUT, Dr.Ing., 259 pp.

The aim of this thesis is to study a removal of cutting fluids by adsorption on chitosan and modified chitosan. 10 adsorbents used in this study are chitosan, blended chitosan/PVA 1:1, benzoyl chitosan, quateraminated chitosan, chitosan-sodium lauryl sulfate, chitosan-hexadecyltrimethy ammonium bromide, chitosan-polyoxyethylene sorbitanmonooleate, blended chitosan/PVA-sodium lauryl sulfate, blended chitosan/PVA-hexadecyltrimethy ammonium bromide and blended chitosan/PVA-polyoxyethylene sorbitanmonooleate. Adsorption capacity of chitosan-sodium lauryl sulfate is the highest at pH 3 with amount of 2516 mg/g. After increasing pH of cutting fluids from pH 7 to 11, it can adsorb the cutting fluids from 747 to 309 mg/g. The adsorption capacity of adsorbents will be better when adding either NaCl or $CaCl_2$. The chitosan-sodium lauryl sulfate can adsorb cutting fluids through hydrophobic interaction. The significant uptake of cutting fluids on all adsorbents is supported by analysis contact angle, SEM, FT-IR, CHN and heating value. Langmuir, Freundlich and BET models were applied to describe the experimental isotherms. The experimental data fitted well with pseudo-second-order kinetic model. The cutting fluids adsorption was found to be controlled by intraparticle diffusion stage. The rate of adsorption cutting fluid increased with increasing temperature. The adsorption of cutting fluids is endothermic reaction. The bed depth/service time model can be used to predict the adsorption performance in a case when there is a change in flow rate.

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Field of study CHEMICAL TECHNOLOGY Advisor's signature

Academic year 2006 Co-advisor's signature

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NOMENCLATRUE

Γ	Surface density (mole/area)
γ	Surface tension
C	Concentration (mg/l)
R	Gas constant (J/mol-K)
T	Absolute temperature (K)
q_0	Maximum adsorption at monolayer coverage (mg/g)
q_e	Moles of adsorbate per mass of adsorbent at equilibrium or adsorption capacity (mg/g)
K_L	Langmuir constant (l/mg)
K_F	Freundlich constant
n	Constant depicting the adsorption intensity
x	Amount of cutting fluids adsorbed (g)
m	Weight of adsorbents (g)
x_m	Amount of cutting fluid adsorbed in forming a complete monolayer (mg/g)
K_B	BET constant
C_s	Saturation concentration of the adsorbate in solution (mg/l)
C_o	Initial cutting fluid concentration (mg/l)
C_e	Final or equilibrium synthetic cutting fluids concentration (mg/l)
V	Volume of wastewater or solution (l)
m	Weight of adsorbents (g)
S	Percent swelling of adsorbent
W_1	Weight of adsorbent before added deionized (g)
W_2	Weight of adsorbent after filtration by screen (g)
H	Humidity of adsorbent

S_{max} Amount of cutting fluids removed by the adsorption zone if completely exhausted

Z Bed depth of column (cm)

v Influent linear velocity (cm/min)

N_0 Adsorption capacity of adsorbent (mg/g)

K_a Rate constant in the BDST model (l/mg-min)

M_1	Weight of adsorbent before incubated (g)
M_2	Weight of adsorbent after incubated (g)
H_g	Gross heat of combustion (J/g)
W	Energy equivalent of calorimeter (J/K)
e_1	Correction in calories for heat of formation of nitric acid (J)
e_2	Correction in calories for heat of formation of sulfuric acid (J)
e_3	Correction in calories for heat of formation of fuse wire (J)
M	Weight of sample (g)
k_a	Adsorption rate constant
k_d	Desorption rate constant
θ	Coverage fraction ($0 \leq \theta \leq 1$)
C_t	Molar concentration of solute at any time (mg/l)
m_c	Mass of sorbent (g)
q_m	Maximum capacity of sorbent
M_w	Molar weight of solute (g/mol)
θ_e	Equilibrium coverage fraction
t	Time (min)
k_1	Rate constant of the pseudo-first-order model (min^{-1})
k_2	Rate constant of pseudo-second-order adsorption (mg/g-min)
r	Particle radius
D	Diffusivity within the particle
k_i	Intraparticle diffusion rate constant (g/g $min^{-0.5}$)
K_d	Adsorption rate constant (min^{-1})
C_a	Concentration of effluent cutting fluids at any particular time (mg/l)

h_P Planck's constant (J-sec)

ΔH Enthalpy change during adsorption (kJ/mol)

ΔS Entropy change during adsorption (J/mol-K)

κ Boltzmann's constant (J/K)

ΔG Gibb free energy (kJ/mol)

A Arrhenius energy (min^{-1})

E_a Activation energy (kJ/mol)

t_z Time required for the adsorption zone (min)

V_s Total volume of cutting fluid spiked water treated between breakthrough and exhaustion (l)

Q_w Influent flow rate (cm^3/min)

t_E Time required for the adsorption zone to become established and move completely out of the bed (min)

V_E Total volume of cutting fluids spiked water treated to the point of exhaustion (l)

U_z Rate of the adsorption zone (cm/min)

h_z Height of the adsorption zone (cm)

h Height of bed depth (cm)

t_f Time required for the adsorption zone to initially form (min)

F Breakthrough fraction

V_B Total volume of cutting fluids spiked water to the point of breakthrough (l)

S_z Amount of cutting fluids that has been removed by the adsorption zone from breakthrough to exhaustion