บันทึกข้อความ

ส่วนราชการ ภาควิชาวิศวกรรมเคมี คณะวิศวกรรมศาสตร์ มหาวิทยาลัยอุบลราชธานี โทร. 3343

ที่ ศธ 0529.8.3/ ว๑๗๒ **วันที่** 09 มี.ค. 2559

เรื่อง ขอรับทุนการเสนอผลงานวิจัย/ผลงานทางวิชาการ แบบ Oral Presentation ในต่างประเทศ ประจำปีงบประมาณ 2558

เรียน **รอง**คณบดีฝ่ายวิจัยและบริการ ผ่านหัวหน้าภาควิชาวิศวกรรมเคมี

ด้วย ข้าพเจ้า ดร.จักรกฤษณ์ อัมพุช ตำแหน่งผู้ช่วยศาสตราจารย์ สังกัดภาควิชาวิศวกรรมเคมี คณะวิศวกรรมศาสตร์ ได้รับการตอบรับให้นำเสนอบทความ “Removal of methylene blue from aqueous solution by using surfactant modified pomelo peel” ด้วยวาจา (Oral Presentation) ในงานประชุมวิชาการ International science and technology conference (ISTEC) ระหว่างวันที่ 13 ถึง 15 กรกฎาคม 2559 ณ ประเทศออสเตรีย

ข้าพเจ้ามีความประสงค์ขออนุมัติเงินสนับสนุน เพื่อนำเสนอบทความทางวิชาการดังกล่าวเป็นจำนวนเงินตามที่จ่ายจริงแต่ไม่เกิน 40,000 บาท (สี่หมื่นบาทถ้วน) ซึ่งข้าพเจ้าได้แนบเอกสารประกอบการพิจารณา จำนวน 1 ชุด ตามลำดับ ดังนี้ 1.จดหมายตอบรับร่วมประชุม International science and technology conference (ISTEC) 2.รายละเอียดของการจัดประชุม 3.บทความที่จะนำไปเสนอต่อที่ประชุม

จึงเรียนมาเพื่อโปรดพิจารณา

จักรกฤษณ์ อัมพุช
(ผู้ช่วยศาสตราจารย์ ดร.จักรกฤษณ์ อัมพุช)
อาจารย์สังกัดภาควิชาวิศวกรรมเคมี

เรียน รองคณบดีฝ่ายวิจัยฯ
เพื่อโปรดพิจารณา
09 มี.ค. 2559

เรียน รองคณบดีฝ่ายวิจัยและบริการวิชาการ
ตามที่ ผศ.ดร.จักรกฤษณ์ อัมพุช
ได้ขอทุนนำเสนอผลงานวิจัยระดับนานาชาติ
ในต่างประเทศ ในเบื้องต้น ได้ตรวจสอบแล้ว
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โครงการประชุมวิชาการระดับนานาชาติเพื่อเสนอผลงานวิจัย

1. ชื่องานประชุม	International science and technology conference (ISTEC) ระหว่างวันที่ 13 ถึง 15 กรกฎาคม 2559 ณ กรุงเวียนนา ประเทศออสเตรีย
2. สถานที่	ประเทศออสเตรีย
3. ผู้ขอรับทุน	ผู้ช่วยศาสตราจารย์ ดร.จักรกฤษณ์ อัมพุช สังกัดภาควิชาวิศวกรรมเคมี คณะวิศวกรรมศาสตร์

4. หลักการและเหตุผล

ตามที่ความร่วมมือระหว่าง Governors State University กับ Vienna University of Technology และ Sakaya University ได้จัดการประชุมทางวิชาการ International science and technology conference (ISTEC) ระหว่างวันที่ 13 ถึง 15 กรกฎาคม 2559 ณ ประเทศออสเตรีย ผู้ช่วยศาสตราจารย์ ดร.จักรกฤษณ์ อัมพุช ได้ส่งผลงานวิจัยและได้รับการตอบรับให้นำเสนอบทความ “Removal of methylene blue from aqueous solution by using surfactant modified pomelo peel” ด้วยวาจา การนำเสนอผลงานดังกล่าวเป็นการเผยแพร่ความรู้ทางด้านการจัดการสิ่งแวดล้อมระดับชุมชน ภายในจังหวัดอุบลราชธานี ประเทศไทย ซึ่งเป็นปัญหารุนแรงในปัจจุบัน รวมทั้งเป็นการแลกเปลี่ยนความรู้และสร้างเครือข่ายนักวิจัยในระดับนานาชาติ ตลอดจนเป็นการสร้างชื่อเสียงให้กับมหาวิทยาลัยและประเทศไทย

5. วัตถุประสงค์

- เพื่อเผยแพร่ผลงานวิจัยเรื่อง Removal of methylene blue from aqueous solution by using surfactant modified pomelo peel
- เพื่อเข้าร่วมแลกเปลี่ยนความรู้จากวิทยากรผู้เชี่ยวชาญอื่น เพื่อส่งเสริมพัฒนาผลงานวิจัย
- เพื่อศึกษาเรียนรู้วิทยาการสมัยใหม่ เพื่อใช้พัฒนาศักยภาพงานวิจัยและงานสอนต่อไป

6. ระยะเวลาดำเนินงาน

ระยะเวลารวม 7 วัน (รวมวันเดินทางตั้งแต่มหาวิทยาลัยอุบลราชธานี) ระหว่างวันที่ 11 กรกฎาคม 2559 ถึง 17 กรกฎาคม 2559

7. ประโยชน์ที่คาดว่าจะได้รับ

- ได้มีโอกาสเผยแพร่ผลงานวิจัย คณะวิศวกรรมศาสตร์ และมหาวิทยาลัยต่อนักวิชาการจากนานาชาติ
- ได้มีโอกาสเผยแพร่ผลงานวิจัยและแลกเปลี่ยนองค์ความรู้ระหว่างนักวิจัยจากประเทศต่าง ๆ
- ได้มีโอกาสเพิ่มพูนความรู้ทางด้านการจัดการสิ่งแวดล้อมจากงานประชุมนี้

8. งบประมาณ

ประมาณการค่าใช้จ่ายการนำเสนอผลงานวิจัย

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4. ค่าเบี้ยเลี้ยง	
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4.2 ค่าเบี้ยเลี้ยงระหว่างวันที่ 11 ธันวาคม ถึง 17 ธันวาคม 2554 (4 วัน)	8,400
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Chakkrit Umpuch <chakkrit.u@ubu.ac.th>

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1 ข้อความ

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Best regards

Prof. Dr. Mustafa S. DUNDAR
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Dear Chakkrit Umpuch,

We are pleased to inform you that the Advisory Board of ISTEC 2016 - International Science and Technology Conference, after rigorous peer-blind review by 2 reviewers, has decided to **ACCEPT** your article to be presented at ISTEC 2016 conference.

ISTEC 2016 will be held in Vienna, AUSTRIA, July 13-15, 2016.

Paper Title : Adsorption of methylene blue from aqueous solution by using surfactant modifed pomelo peel

Presentation Type : Oral Presentation

Thank you in advance for your contribution toward the success of ISTEC; We look forward to welcoming you to ISTEC 2016.

Sincerely,

Prof. Dr. M. Şahin DÜNDAR
Coordinator
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REMOVAL OF METHYLENE BLUE FROM AQUEOUS SOLUTION BY USING SURFACTANT MODIFIED POMELO PEEL

Chakkrit Umpuch and Pariwat Namduang

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Abstract: This work, the potential of using surfactant modified pomelo peel for adsorbing methylene blue was studied. Experiments were carried out as function of contact time, initial adsorbate concentration, initial solution pH and temperature. The dynamic data fit well with the pseudo-second-order kinetic model (R^2> 0.9999) with the apparent activation energy of +45.67 kJ/mol. The Langmuir model agrees very well with the experimental data (R^2>0.9900). On the basis of the Langmuir analysis, the maximum adsorption capacities were determined to be 294.20 mg/g at 25°C, 304.31 mg/g at 35 °C and 306.56 mg/g at 45°C and 308.42 mg/g at 55°C. The negative values of gibbs free energy indicate the spontaneous nature of the adsorption. It is suggested that the adsorption is likely to be chemical adsorption.

Keywords: surfactant modified pomelo peel, methylene blue, adsorption, kinetics, isotherm

INTRODUCTION

Water pollution from dye contamination in natural stream in Ubon Ratchathani province, Thailand is one of significant problems. The problem gains more serious due to the rapid growth of household scale textile industries to meet increasing population and exporting demands. Two types of dye which are natural and synthetic dyes are usually used in dyeing process. The synthetic dyes are preferred because of their bright and lasting colors, resistance to heat and light and ease applications. After dyeing process, approximately 40% dye amount is left in water body and usually find their way into nearby rivers and/or spaces under houses. The synthetic dyes are high water solubility, heat and light resistance and low biodegradability (Chuah et al., 2005). High amount of accumulated synthetic dyes in water support can cause unsightly scenery, obstruction of light transmission into water body and being harmful to humans, animal, and aquatic life. Therefore, it is very important to remove the synthetic dyes from wastewater before discharge. In order to persuade the villagers in household scale industries concern water pollution and pay attention to wastewater treatment, the treatment methods should be simple, fast and low cost. Adsorption technology is one of treatment methods which can achieve those suggestions. Adsorption process is the adhesion of dye molecules, adsorbate, from wastewater to a solid surface, adsorbent.

The activated carbon is a well known adsorbent and widely used in dye removal from wastewater; however, the commercial activated carbon is expensive due to high energy consumption during its preparation. Recently, alternative ways to develop biosorbent from natural materials as biosorbent also exist to decrease the cost. The materials that have received considerable attention to use biosorbent for dye removal are fruit peel, corncob, sugarcane bagasses, rice hull, bacteria, fungi and algae (Jayarajan et al., 2011; Umpuch and Jutarat, 2013). Pomelo is a fruit which is widely grown in Thailand so that it is plentiful and cheap. Pomelo peel (PP) is composed of insoluble monomers such as pectin, cellulose and hemicelluloses which have important functional groups such as carboxyl and hydroxyl groups. These functional groups can interact with cations in aqueous solution.

In addition, the adsorption capacity of biosorbent can enhance by various modifications (Wibulswas, 2004; Charuwong and Kiattikomol, 2004). Adsolubilization technology is a process to form admicelle of cationic surfactant on the external surface of adsorbent. The adsolublization causes the surface properties of adsorbent altering from hydrophilic to hydrophobic. It has been proven that the surfactant modified biosorbent is effective for organic compound adsorption. However, the adsorption of cationic dyes by surfactant modified biosorbent is seldom studied.

This study focused on preparation of surfactant modified pomelo peel (SMPP) which is a novel material for cationic dye, methylene blue, removal from aqueous solution. Experiments were carried out as function of contact time, initial dye concentration, initial solution pH and temperature. Also, the dye removal efficiency of SMPP was determined by single-stage batch adsorption tests including kinetic model, adsorption isotherms and thermodynamic study.

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MATERIALS AND METHODS

Methylene blue (MB) supplied by Aldrich, Ireland was used as an adsorbate. Distilled water was employed for preparing all the solutions and reagents. MB has a molecular weight of 373.9 g/mol which corresponds to methylene blue hydrochloride with three group of water ($C_{16}H_{18}ClN_3S.3H_2O$). A stock solution of MB was prepared by dissolving 1.0 g in 1 L of distilled water, and the solutions for adsorption tests were prepared from the stock solution to the desired concentration by successive dilutions.

The natural pomelo peel was purchased from a local market at Warin Chamrap, Ubon Ratchathani province, Thailand as a solid waste. The yellow-green peel (flavedo) was removed from the pomelo peel with a knife. The residue, white spongy peel (albedo), was then washed with distilled water several times to remove all impurities. Then, the clean material was dried at a temperature of 40°C in an air-circulating oven until weight being constant. The dried pomelo peel was crushed and shredded in a blender for about 15 min and sieved to obtain a particle size below 300 μm, designated as precursor. An amount of 1.0 g of the precursor was treated with 100 mL of 1000 mg/L tetradecyltrimethylammonium bromide ($C_{17}H_{38}NBr$) surfactant. Agitation at 200 rpm was allowed for 15 min at room temperature using an orbital shaker. Afterwards, the surfactant modified pomelo peel (SMPP) particles were filtered with a microfilter (Whatman, UK), washed with distilled water several times to remove superficially retained surfactant, and dried in an oven at 40 °C until weight being constant. To have uniform modification and reproducible results, the SMPP particles were sieved (50 mesh) before use for adsorption studies. All adsorbents were packed in plastic bags and stored in desiccators for further use.

The batch sorption experiments were carried out in a set of Erlenmeyer flasks (250 mL) by agitating desired amounts of SMPP particles with 100 mL of dye solutions of desired concentration and pH, in an isothermal shaker. A series of adsorption experiments were investigated in different operating conditions related to the contact time, initial MB concentration, initial solution pH and temperature. First, the effect of contact time was investigated. A series of 250 mL Erlenmeyer flasks containing 100 mL of the 300 mg/L MB solutions were mixed with 0.1 g of SMPP. These flasks were closed with paraffin to avoid evaporation and then horizontally shaken at 200 rpm. The samples were measured at 2, 5, 15, 30 and 60 min. Second, the effect of initial MB concentrations was carried out in the same fashion with that in the first experiment, but the initial concentrations were varied in a range of 50 to 300 mg/L of MB solution ($pH_0 = 5.0$) and the contact time was assigned at 24 hours. The effect of the initial solution pH was carried out in the same manner with the second experiments but varying the pH_0 of 300 mg/L MB solution from 2.0 to 10.0. Finally, the effect of temperature was investigated by repeating the first and second experiments but investigating at other temperatures such as 35, 45 and 55°C (Umpuch and Jutarat, 2012).

The collecting samples were filtered by micro-filter to remove adsorbent particles and the MB concentration in the filtrate was analyzed by UV-Vis Spectrophotometer at wavelength corresponding to the maximum absorbance for MB of 663 nm. The absorbance values were converted to MB concentration by calibration curve. The MB adsorbed quantity and the removal MB percentage (%MB Removal) were calculated using the following equations:

$$q_t = \frac{V(C_0 - C_t)}{m} \tag{1}$$

$$\%\ MB\ Removal = \frac{C_0 - C_t}{C_0} \times 100\,\% \tag{2}$$

where q_t (mg/g) is the quantity of MB biosorbed per unit mass of biosorbent, C_0 (mg/L) is the initial MB concentration, C_t (mg/L) is the MB concentration after biosorption, m (g) is the mass of biosorbent, and V (L) is the volume of aqueous solution. In addition, the %MB removal of pomelo peel and SMPP determined by using second experiment but fixed initial MB concentration as 300 mg/L were 46.30% and 65.74%, respectively.

RESULTS AND DISCUSSION

The effect of contact time on the instantaneous adsorption capacities of MB by SMPP, q_t, is shown in Fig.1. The dye uptakes increased in the first 2 min and then gradually increased with time until reaching a constant. The rapid rate in the initial stage was probably due to the abundant availability of active sites on the external surface of the SMPP particles. The adsorption rate gradually increased in the later stages because of the reduction in available active sites. The saturation of MB molecules on the SMPP was addressed at the final stage. The equilibrium time required for the adsorption of the MB was approximately 30 min.

To find the mechanism controlling the adsorption process, pseudo-first-order, pseudo-second order, and intraparticle diffusion models were used to check the experimental data. The q_t (mg/g) is the amount of MB

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adsorbed at time t. The pseudo-first order kinetic model is normally applicable for only the initial 30 min of adsorption process. If the diffusion rate of adsorbate across the boundary layer to adsorbent surface is at a rate of limiting step, the kinetic data are well fitted to the pseudo-first order model (Lagergren and Svenska, 1898). It is generally expressed as follows:

$$\ln(q_e - q_t) = \ln q_e - k_1 t \tag{3}$$

where k_1 (min^{-1}) is the rate constant of first-order adsorption.

The pseudo-second order kinetic model was proposed by Ho in 1995 (Ho and McKay, 1998). If the chemical sorption is the rate-limiting step, the experimental data follow the pseudo-second order expression according to Eq.(4). It is expressed as:

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{1}{q_e} t \tag{4}$$

where k_2 (min^{-1}) is the rate constant of second-order adsorption.

If the diffusion of cadmium ions into the pores and capillaries of the adsorbent is the rate of limiting step, the adsorption data can be presented by the following Eq.(5):

$$q_t = k_p t^{1/2} + C \tag{5}$$

where k_p represents intraparticle diffusion rate constant ($\mathrm{mg/(g.min^{1/2})}$) and C is a constant (mg/g) which gives information on the thickness of the boundary layer.

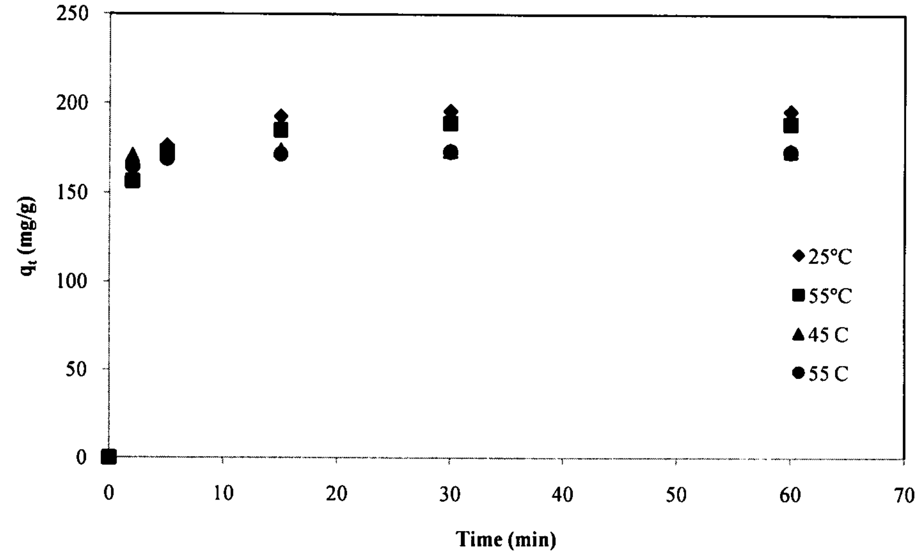

Figure 1. Effect of temperature on the adsorption of MB onto SMPP for a solution initially containing 300 mg/L of MB as a function of time.

Table 1 Constants from three kinetic models for MB adsorption on SMPP

Model	**Parameters**	**T(°C)**			
		25	**35**	**45**	**55**
	$q_{e,exp}$(mg/g)	195.83	189.17	173.89	173.33
Pseudo-first order	k_1 (min^{-1})	1.68	1.62	1.24	1.29
	$q_{e,cal}$ (mg/g)	6.75×10^{31}	3.61×10^{30}	6.98×10^{22}	1.17×10^{24}
	R^2	0.2573	0.2547	0.1631	0.1834
Pseudo-second order	k_2 (g/(mg*min))	0.0163	0.0176	0.567	0.0639
	$q_{e,cal}$ (mg/g)	196.97	189.97	173.93	173.58
	R^2	0.9999	0.9999	0.9999	0.9999
Intraparticle diffusion	k_p ($\mathrm{mg/(g.min^{1/2})}$)	19.03	18.33	15.09	15.43

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	C (mg/g)	88.13	85.31	92.23	88.68
	R^2	0.4981	0.4953	0.3662	0.3952

The calculated values of $q_{e,cal}$ (Table 1) from the pseudo-first-order kinetics model and intraparticle diffusion model were dramatically lower than the experimental value (q_{exp}). The linear plot of t/q_t against t according to Eq. (4) was observed. The constant k_2 and the corresponding linear regression correlation coefficient values, R^2, are given in Table 1. As the values of R^2 were limited to unity (R^2>0.9986), the adsorption data conform to the pseudo-second order model. This indicated that the rate of limiting step was the formation of chemical bonding between the MB and the dissociated functional groups on the surface of the SMPP.

The activation parameter can be determined by the Arrhenius equation. The slope of the plot of log k_2 vs. 1/T can then be used to evaluated the activation energy, E_a, according to equation (6). The Arrhenius equation is expressed as:

$$\log k_2 = \log A - \frac{E_a}{RT} \tag{6}$$

where E_a is the activation energy (J/mol) and A is the Arrhenius factor (g/(mol.s))

The experimental results obtained gave E_a = +45.67 kJ/mol for the adsorption of MB onto SMPP. Low E_a values (<42 kJ/mol) indicate diffusion control processes, and the higher E_a values (>42 kJ/mol) indicate chemically controlled process. In this study, low value of the E_a indicates that the adsorption process of MB adsorption on SMPP might be a chemical adsorption.

The study of adsorption isotherm is fundamental, and plays an important role in the determination of the maximal capacity of adsorbent. Adsorption isotherm of MB on SMPP which is the plot of MB concentration in solid vs. MB concentration in liquid at equilibrium stage was illustrated in Fig.2.

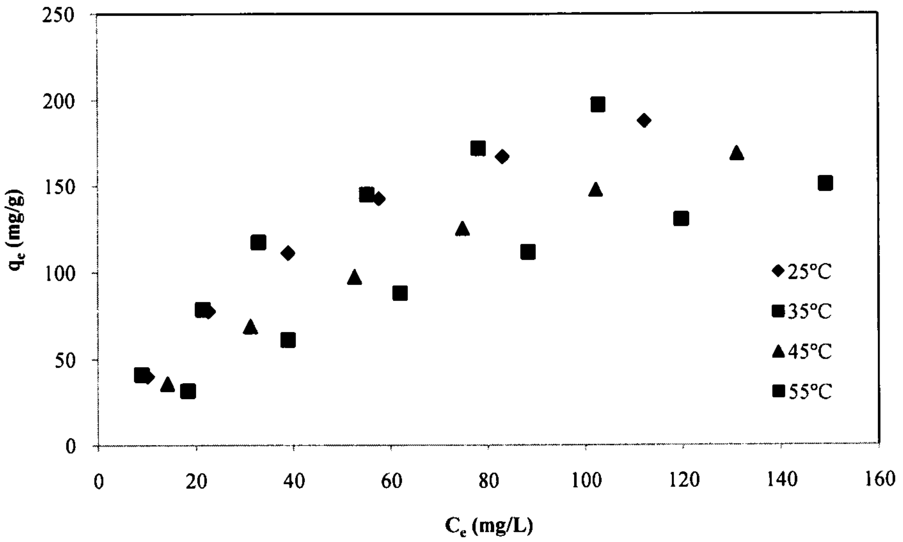

Figure 2. Effect of temperature on the adsorption of MB onto SMPP for a solution initially containing 300 mg/L of SMPP as a function of equilibrium MB concentration.

The equilibrium data usually were correlated by well established isotherm models such as Langmuir and Freudlich isotherms. For the adsorption on a totally homogeneous surface, generally the Langmuir equation applies because here interactions between adsorbed molecules are negligible. The Langmuir equation is most often used to describe equilibrium sorption isotherm (Anwar et al., 2010) which is valid for monolayer sorption with a finite number of identical sites. The linear form of Langmuir isotherm is given below.

$$\frac{C_e}{q_e} = \frac{C_e}{q_m} + \frac{1}{K_L q_m} \tag{7}$$

where q_m (mg/g) is the maximum sorption of monolayer, C_e (mg/L) is a final equilibrium concentration of cadmium, q_e (mg/g) is the MB adsorbed per unit weight of the SMPP at final equilibrium concentration, and K_L

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(ml/g) is the Langmuir constant related to the affinity of binding sites.

The essential characteristics of the Langmuir isotherm can be expressed by means of "R_L" which is a dimensionless constant referred to as a separation factor of equilibrium parameter. The R_L is defined by

$$R_L = \frac{1}{1 + K_L C_0} \tag{8}$$

This parameter suggests the type of isotherm is irreversible ($R_L=0$), favorable ($0<R_L<1$), linear ($R_L=1$), or unfavorable ($R_L>1$). As can be seen from Table 2, the R_L values are between 0 and 1.0, indicating that the adsorption of MB onto SMPP is favorable.

The widely used empirical Freundlich equation based on sorption on a heterogeneous surface is given by

$$\log(q_e) = \log(K_F) + \frac{1}{n}\log(C_e) \tag{9}$$

where K_F ($mg^{1-1/n}.L^{1/n}.g^{-1}$) and n are the physical constants of the Freundlich isotherm. The K_F and n are the indicators of adsorption capacity and adsorption intensity respectively (Salleh et al., 2011).

The results showed the Langmuir isotherm was best fitted to the experimental data for MB indicating that the monolayer of MB molecules covers along the SMPP surface. Table 2 shows the monolayer capacity of absorbed MB onto SMPP was 294.20 mg/g at 25°C, 304.31 mg/g at 35 °C and 306.56 mg/g at 45°C and 308.42 mg/g at 55°C.

Table 2: Isotherm constants and correlation coefficients for the adsorption of MB on SMPP at different temperatures

Model	Parameters	T(°C)			
		25	35	45	55
Langmuir isotherm	q_m (mg/g)	294.11	304.31	306.56	308.42
	K_L (L/mg)	0.0159	0.0174	9.31×10^{-3}	6.47×10^{-3}
	R_L	0.173	0.161	0.264	0.340
	R^2	0.9993	0.9907	0.9975	0.9952
Freundlich isotherm	K_F (l/g)	9.89	11.00	5.97	3.90
	n	1.56	1.57	1.44	1.35
	R^2	0.9839	0.9814	0.9962	0.9915

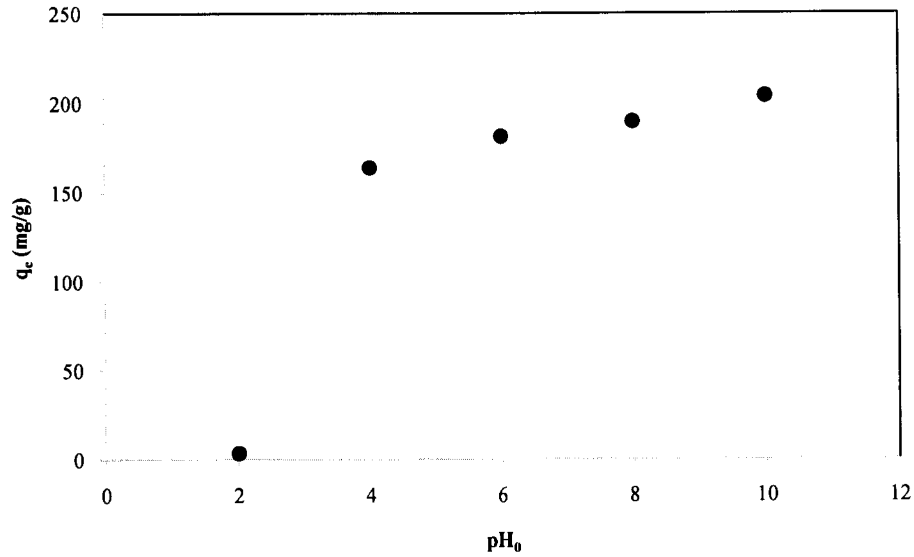

Figure 2. Effect of initial solution pH on the adsorption of MB onto SMPP for a solution initially containing 300 mg/L of SMPP.

The effect of initial solution pH on the equilibrium adsorption capacities of MB by SMPP, q_e, is shown in Fig.2. The uptakes of the MB dye increased with increase in the initial solution pH. The sorption capacity increased greatly when the pH increased from 2.0 to 4.0 and gradually increased further when the pH increased from 4.0 to

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10.0. The interaction between MB and admicelle coating on the PP surface is suggested as hydrophobic-hydrophobic interactions since the MB is co-ions with positive charge on the adsorbent surface. At acidic medium, there is a small quantity of hydroxide ions so that the MB is in cationic form. The adsorption capacity is very small in this condition because electrostatic repulsion between the MB and active site. On the other hand, the increase of pH levels provides higher amount of hydroxide ion which compensate with MB cations to form neutral molecules. In addition, the positive charge on the adsorbent surface also compensate with hydroxide ions become neutral surface. Consequently, the electrostatic repulsion is weaker and the MB and admicelle forms hydrophobic-hydrophobic interactions. This results in higher adsorption capacity of MB in the alkali medium.

The effect of operating temperature on the instantaneous and equilibrium adsorption capacities of MB by SMPP is shown in Fig.1 and 2. The increase of temperature in the system caused a decrease of the adsorption capacity. This indicated that the reaction was exothermic process. This result was in accordance with those observed in the previous literature (Yan et al., 2007). Thermodynamic parameters can be determined from the variation of the thermodynamic equilibrium constant K_L with temperature.

$$\Delta G^0 = -RT \ln K_L \tag{9}$$

where R is the universal gas constant (8.314 J/mol.K) and T is temperature in Kelvin. The average standard enthalpy change (ΔH^0) and the standard entropy change (ΔS^0) are determined from the Van't Hoff equation (Umpuch and Sakaew, 2013).

$$\ln K_L = -\frac{\Delta H^0}{RT} + \frac{\Delta S^0}{R} \tag{10}$$

As seen in Table 3, all ΔG^0 shifted to a less negative value when the temperature increased suggesting the adsorption occurred less spontaneously at higher temperature. The negative value of the enthalpy change (ΔH°) indicated that the sorption was an exothermic process. This also suggested that the adsorption process takes place without energy consumption. The negative value of entropy change (ΔS°) corresponded to an decrease in the degree of freedom of the adsorbed species. However, a little change of entropy can be observed showing that SMPP did not change significantly as a result of adsorption.

Table 3: Thermodynamic parameters for the adsorption of MB on SMPP

T(°C)	K_L (L/mol)	ΔG° (kJ/mol)	ΔH° (kJ/mol)	ΔS° (kJ/(mol.K))
25	5.95	-4.42	-26.75	-0.080
35	6.51	-4.64		
45	3.48	-3.09		
55	2.42	-2.19		

CONCLUSION

The cationic surfactant adsolubilized on pomelo peel caused a presence of admicelle which is organophilic on the external surface of the precursor enhancing adsorption capacity to MB blue dyes. The MB uptakes rapidly increased in the first 2 min and achieved equilibrium at 30 min. The SMPP sorbs MB effectively in alkali solution and sorption of MB is strongly pH dependent. The sorption process is well described by Langmuir and Freundlich equations. The kinetic study demonstrated that the adsorption kinetics followed pseudo-second order kinetic model. The activation energy of +45.67 kJ/mol was determined. The calculated ΔH^0, ΔS^0 and ΔG^0 suggested that the adsorption was exothermic and spontaneous. From the above results, the SMPP was an effective adsorbent for the removal of the organic dyes from synthetic effluents.

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