Electronic Supplementary Information for

Removal of methyl violet dye by adsorption onto N-benzyltriazole derivatized dextran

Eunae Cho\textsuperscript{a}, Muhammad Nazi Tahir\textsuperscript{b}, Hwanhee Kim\textsuperscript{c}, Jae-Hyuk Yu\textsuperscript{d}, Seunho Jung\textsuperscript{c,*}

\textsuperscript{a} Institute for ubiquitous information technology and applications (UBITA), Konkuk University, Seoul 143-701, South Korea

\textsuperscript{b} The Danish Polymer Centre, Department of Chemical and Biochemical Engineering Danmarks Tekniske Universitet (DTU), 2880 Kgs. Lyngby, Denmark

\textsuperscript{c} Department of Bioscience and Biotechnology, Bio/Molecular Informatics Center & Institute of Ubiquitous Information Technology and Applications (CBRU), Konkuk University, 1 Hwayangdong, Gwangjin-gu, Seoul 143-701, South Korea

\textsuperscript{d} Departments of Bacteriology and Genetics, University of Wisconsin, Madison, Wisconsin 53706, USA

\* Corresponding author

Seunho Jung, Ph. D.

Mailing address: Professor, Department of Bioscience and Biotechnology, Bio/Molecular Informatics Center & Center for Biotechnology Research in UBITA, Konkuk University, 1 Hwayang-dong Gwangjin-gu, Seoul 143-701, South Korea

Tel: 82-2-450-3520; fax: 82-2-452-3611; e-mail: shjung@konkuk.ac.kr
S1. Standard Methods

S1.1. Equilibrium studies

The prepared polysaccharide adsorbent was added to the dye solution and stirred at the fixed temperature in a sealed container. After the equilibrium was reached, the solution was separated by centrifugation at 13,000 rpm for 5 min. The absorbance of the supernatant was measured spectrophotometrically, and the residual dye concentration was measured both at time \( t = 0 \) and after equilibrium, at a wavelength of 583 nm. The amount of adsorption of the dye onto the adsorbent at equilibrium, \( q_e \) (mg/g), was calculated by:

\[
q_e = \frac{[(C_0 - C_e) \times V]}{m}
\]

where \( C_0 \) and \( C_e \) (mg/L) are the liquid phase concentrations of the dye initially and at equilibrium, respectively, \( V \) is the volume of the solution (L), and \( m \) is the mass of the adsorbent used (g).

The dye removal percentage was calculated as follows:

\[
\text{% Removal} = \left[ \frac{(C_0 - C_e)}{C_0} \right] \times 100
\]

S1.2. Adsorption isotherm

The equilibrium sorption of the absorbate by the adsorbent was correlated with the Langmuir, Freundlich, and Temkin isotherm models; they are represented by the following equations, (3), (4), and (5), respectively:

\[
\frac{1}{q_e} = \frac{1}{q_m} + \frac{1}{(q_m K_L C_e)}
\]

\[
\ln q_e = \ln K_F + \left( \frac{1}{n} \right) (\ln C_e)
\]

\[
q_e = B \ln A_T + B \ln C_e
\]

where \( q_m \) is the maximum adsorption capacity of the adsorbent (mg/g), \( K_L \) is the Langmuir isotherm constant (L/mg), \( K_F \) is the Freundlich isotherm constant (mg/g), \( n \) represents the intensity of adsorption, \( B \) is a constant related to the heat of sorption (J/mol), and \( A_T \) is the Temkin isotherm equilibrium binding constant (L/g).

The essential characteristics of the Langmuir isotherm may be expressed in terms of an equilibrium parameter, \( R_L \), which is a dimensionless constant, also referred to as the separation factor:

\[
R_L = \frac{1}{(1+K_L C_0)}
\]

where \( R_L \) values indicate whether the isotherm will be irreversible \( (R_L = 0) \), favorable \( (0 < R_L < 1) \), linear \( (R_L = 1) \), or unfavorable \( (R_L > 1) \).
SI.3. Adsorption kinetics

The pseudo-second order kinetic model was used to analyze the experimental data. The rate of a pseudo-second order reaction is dependent on the amount of sorbate adsorbed on the surface of the adsorbent and the amount adsorbed at equilibrium. The pseudo-second order model can be represented by the following equation:

\[
t/q_t = q/k_2 q_e^2 + t/q_e
\]

where \( k_2 \) (g/mg·min) is the second-order rate constant of adsorption.
### Table S1. Elemental analysis and atomic ratios of carbohydrates.

<table>
<thead>
<tr>
<th></th>
<th>C [%]</th>
<th>H [%]</th>
<th>N [%]</th>
<th>O [%]</th>
<th>(N+O)/C</th>
<th>H/C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dextran</td>
<td>39.47</td>
<td>6.78</td>
<td>0</td>
<td>50.75</td>
<td>0.96</td>
<td>2.06</td>
</tr>
<tr>
<td>N-benzyltriazole derivatized dextran</td>
<td>54.80</td>
<td>6.67</td>
<td>8.56</td>
<td>26.70</td>
<td>0.50</td>
<td>1.46</td>
</tr>
<tr>
<td>Succinoglycan</td>
<td>38.56</td>
<td>6.35</td>
<td>0</td>
<td>47.55</td>
<td>0.92</td>
<td>1.98</td>
</tr>
<tr>
<td>N-benzyltriazole derivatized succinoglycan</td>
<td>56.53</td>
<td>6.44</td>
<td>9.71</td>
<td>26.22</td>
<td>0.50</td>
<td>1.37</td>
</tr>
</tbody>
</table>

### Table S2. Comparison of maximum adsorption capacities of N-benzyltriazole derivatized dextran with other adsorbents for methyl violet in aqueous solutions.

<table>
<thead>
<tr>
<th>Adsorbent</th>
<th>q&lt;sub&gt;max&lt;/sub&gt; (mg/g)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugarcane dust</td>
<td>50.4</td>
<td>(Ho et al., 2005)&lt;sup&gt;7&lt;/sup&gt;</td>
</tr>
<tr>
<td>Bagasse fly ash</td>
<td>26.2</td>
<td>(Mall et al., 2006)&lt;sup&gt;8&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cross linked amphoteric starch</td>
<td>333.3</td>
<td>(Xu et al., 2006)&lt;sup&gt;9&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sunflower seed hull</td>
<td>92.6</td>
<td>(Hameed et al., 2008)&lt;sup&gt;10&lt;/sup&gt;</td>
</tr>
<tr>
<td>Granular activated carbon</td>
<td>95</td>
<td>(Azizian et al., 2009)&lt;sup&gt;11&lt;/sup&gt;</td>
</tr>
<tr>
<td>Magnetic baker’s yeast biomass</td>
<td>60.8</td>
<td>(Tian et al., 2010)&lt;sup&gt;12&lt;/sup&gt;</td>
</tr>
<tr>
<td>Almond shell</td>
<td>76.3</td>
<td>(Duran et al., 2011)&lt;sup&gt;13&lt;/sup&gt;</td>
</tr>
<tr>
<td>Halloysite nanotubes</td>
<td>113.6</td>
<td>(Liu et al., 2011)&lt;sup&gt;14&lt;/sup&gt;</td>
</tr>
<tr>
<td>Peanut straw char</td>
<td>101</td>
<td>(Xu et al., 2011)&lt;sup&gt;15&lt;/sup&gt;</td>
</tr>
<tr>
<td>Exfoliated graphene oxide</td>
<td>2.47</td>
<td>(Ramesha et al., 2011)&lt;sup&gt;16&lt;/sup&gt;</td>
</tr>
<tr>
<td>h-XG/SiO&lt;sub&gt;2&lt;/sub&gt;-2 nanocomposite</td>
<td>378.8</td>
<td>(Ghorai, et al., 2014)&lt;sup&gt;17&lt;/sup&gt;</td>
</tr>
<tr>
<td>N-benzyltriazole derivatized dextran</td>
<td>95.24</td>
<td>Present study</td>
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Table S3. FT-IR absorption bands of N-benzyltriazole derivatized dextran before and after adsorption.

<table>
<thead>
<tr>
<th>Wavenumber (cm$^{-1}$)</th>
<th>Differences</th>
<th>Assignment</th>
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<tr>
<td>Before adsorption</td>
<td>After adsorption</td>
<td></td>
</tr>
<tr>
<td>3418</td>
<td>3420</td>
<td>+2</td>
</tr>
<tr>
<td>3141</td>
<td>3139</td>
<td>-2</td>
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<tr>
<td>2927</td>
<td>2928</td>
<td>+1</td>
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<tr>
<td>2097</td>
<td>-</td>
<td></td>
</tr>
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<td>1643</td>
<td>1637</td>
<td>-6</td>
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<tr>
<td>-</td>
<td>1587</td>
<td></td>
</tr>
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<td>1435</td>
<td>1436</td>
<td>+1</td>
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<td>1354</td>
<td>1361</td>
<td>+7</td>
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<tr>
<td>1282</td>
<td>1285</td>
<td>+3</td>
</tr>
<tr>
<td>1155</td>
<td>1153</td>
<td>-2</td>
</tr>
<tr>
<td>1017</td>
<td>1020</td>
<td>+3</td>
</tr>
<tr>
<td>698</td>
<td>699</td>
<td>+1</td>
</tr>
</tbody>
</table>

Fig. S1. FT-IR spectrum of methyl violet 2B.
Fig. S2. SEM image (A) and particle size distribution (B) of original dextran.
Fig. S3. Langmuir (A), Freundlich (B), and Tempkin adsorption isotherms (C) for methyl violet 2B on N-benzyltriazole derivatized dextran.

(A) 
\[ \frac{1}{q_e} = \frac{1}{K_L} + \frac{1}{q_m} C_e \]
\[ y = 0.0646x + 0.0105 \]
\[ R^2 = 0.9815 \]

(B) 
\[ \ln q_e = \ln q_m - n \ln C_e \]
\[ y = 0.4641x + 2.7749 \]
\[ R^2 = 0.9787 \]

(C) 
\[ q_e = q_m \cdot (C_e)^n \]
\[ y = 22.73x + 7.2371 \]
\[ R^2 = 0.9433 \]
Fig. S4. Separation factor for methyl violet 2B onto N-benzyltriazole derivatized dextran.

\[ R^2 \text{ vs. } C_0 \text{ (mg/L)} \]

Fig. S5. Effect of temperature on adsorption capacity of N-benzyltriazole derivatized dextran.

\[ \alpha \text{ vs. time (min)} \]

Legend:
- 15 °C
- 35 °C
- 45 °C
- 55 °C
- 75 °C
Fig. S6. Arrhenius plot (A) for determination of activation energy ($E_a$) of adsorption and plot of $\ln(k/\tau)$ against $1/T$ (B) for the determination of free energy of activation $\Delta G^\#$. 

(A) 

(B)
Fig. S7. Determination of the thermodynamic parameters for the adsorption of methyl violet 2B onto N-benzyltriazole derivatized dextran.
References