Supporting Information

Investigating dynamics of excitons in monolayer WSe$_2$
before and after organic super acid treatment

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Figure S1. Measurements of organic super acid treated monolayer WSe\textsubscript{2} (osa-monolayer) by femtosecond pump-probe system. (a) Transient absorption (TA) spectrum of osa-monolayer WSe\textsubscript{2} excited under 400 nm pump pulse with pump fluence of 7.4 \( \mu \text{J cm}^{-2} \). (b) TA spectrum of osa-monolayer WSe\textsubscript{2} excited under 400 nm pump pulse with pump fluence of 76 \( \mu \text{J cm}^{-2} \). (c) TA spectrum of osa-monolayer WSe\textsubscript{2} excited under 610 nm pump pulse with pump fluence of 0.1 \( \mu \text{J cm}^{-2} \). (d) TA spectrum of osa-monolayer WSe\textsubscript{2} excited under 610 nm pump pulse with pump fluence of 0.52 \( \mu \text{J cm}^{-2} \). (e) TA spectrum of osa-monolayer WSe\textsubscript{2} excited under 730 nm pump pulse with pump fluence of 0.12 \( \mu \text{J cm}^{-2} \). (f) TA spectrum of osa-monolayer WSe\textsubscript{2} excited under 730 nm pump pulse with pump fluence of 0.14 \( \mu \text{J cm}^{-2} \).
Figure S2. Measurements of monolayer WSe$_2$ without organic super acid treated by femtosecond pump-probe system. TA spectrum of monolayer WSe$_2$ excited under 610 nm pump pulse with pump fluence of 4.4 μJ cm$^{-2}$. 
Figure S3. Measurements of bulk WSe$_2$ by femtosecond pump-probe system. (a) TA spectrum of bulk WSe$_2$ excited under 400 nm pump pulse with pump fluence of 71 μJ cm$^{-2}$. (b) TA spectrum of bulk WSe$_2$ excited under 400 nm pump pulse with pump fluence of 141 μJ cm$^{-2}$. (c) TA spectrum of bulk WSe$_2$ excited under 800 nm pump pulse with pump fluence of 22 μJ cm$^{-2}$. (d) TA spectrum of bulk WSe$_2$ excited under 800 nm pump pulse with pump fluence of 55 μJ cm$^{-2}$.
Figure S4. The normalized dynamics of A-exciton for bulk WSe$_2$ under 800 nm excitation with three pump fluences. Green line: pump fluence of 11 μJ cm$^{-2}$, purple line: pump fluence of 22 μJ cm$^{-2}$, red line: pump fluence of 54 μJ cm$^{-2}$.
Table S1. The enlargement factor of GSB signal of A exciton for monolayer WSe$_2$ after organic super acid treatment under different pump fluences.

<table>
<thead>
<tr>
<th>610 nm excitation</th>
<th>osa-monolayer WSe$_2$</th>
<th>Untreated monolayer WSe$_2$</th>
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<tr>
<td>ΔO.D. intensity ($\times 10^2$)</td>
<td>0.23</td>
<td>0.84</td>
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<td>Enlargement factor</td>
<td>48</td>
<td>53</td>
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