

## Cover sheet for SI

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## **Appliance of H<sub>2</sub>-based MBfR in advanced nitrogen removal from real municipal secondary effluent**

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**Table S1** The parameters of membrane.

| <b>Item</b>          | <b>Characteristic</b> |
|----------------------|-----------------------|
| Material             | Polypropylene         |
| Inner diameter       | 90 $\mu\text{m}$      |
| Outer diameter       | 200 $\mu\text{m}$     |
| Thickness            | 55 $\mu\text{m}$      |
| Cross-sectional area | 31400 $\mu\text{m}^2$ |
| Porosity             | Nonporous             |
| Property             | Hydrophobicity        |

**Table S2** The ingredients of synthetic wastewater.

| <b>Item</b>                                | <b>Concentration</b> |
|--|----------------------|
| $\text{KH}_2\text{PO}_4$                   | 1 mg/L               |
| $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$  | 5 mg/L               |
| $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$  | 1 mg/L               |
| $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$  | 1 mg/L               |
| $\text{NaHCO}_3$                           | 10 mg/L              |
| $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$  | 100 $\mu\text{g/L}$  |
| $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$  | 30 $\mu\text{g/L}$   |
| $\text{H}_3\text{BO}_3$                    | 300 $\mu\text{g/L}$  |
| $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$  | 200 $\mu\text{g/L}$  |
| $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$  | 10 $\mu\text{g/L}$   |
| $\text{NiCl}_2 \cdot 2\text{H}_2\text{O}$  | 10 $\mu\text{g/L}$   |
| $\text{NaMoO}_4 \cdot 2\text{H}_2\text{O}$ | 30 $\mu\text{g/L}$   |
| $\text{NaSeO}_3$                           | 30 $\mu\text{g/L}$   |

**Table S3** The construction cost of H<sub>2</sub>-MBfR.

| <b>Item</b>        | <b>Specification<br/>(mm)</b> | <b>Quantity</b> | <b>Footprint<br/>(m<sup>2</sup>)</b> | <b>Material</b> | <b>Cost<br/>(CNY)</b> |
|--------------------|-------------------------------|-----------------|--------------------------------------|-----------------|-----------------------|
| Regulating pool    | 10000×8000<br>×5000           | 1               | 80                                   | Brick concrete  | 150,000               |
| MBfR tank          | 5000×6000×<br>1500            | 4               | 120                                  | Stainless steel | 960,000               |
| Equipment room     | 4000×4000×<br>3800            | 1               | 16                                   | Steel           | 180,000               |
| Dosing room        | 4000×4000×<br>3800            | 1               | 16                                   | Steel           | 180,000               |
| Disinfection canal | 10000×110×<br>1000            | 1               | 10                                   | Stainless steel | 100,000               |
| Total              |                               |                 |                                      |                 | 1,570,000             |

**Table S4** Hydrogen utilization efficiency of the MBfR under different HRT.

| HRT(h) | Effluent hydrogen concentration( $\mu\text{g/L}$ ) | Effluent nitrate concentration (mgN/L) | Hydrogen utilization efficiency (%) |
|--------|--|--|-------------------------------------|
| 2.6    | 176.9  | 5.58                                   | 96.3                                |
| 3      | 697.5  | 5.03                                   | 87.4                                |
| 3.5    | 988.2  | 3.68                                   | 84.6                                |
| 4      | 1096.3   | 2.49                                   | 84.1                                |
| 6      | 1383.0   | 0.86                                   | 83.1                                |

**Table S5** The calculated values used for kinetic parameters estimation.

| <b>Item</b>           | <b>Value</b>      |
|-----------------------|-------------------|
| Reynolds number       | 1325              |
| Sherwood number       | 2391              |
| Schmidt number        | 471.8             |
| Characteristic length | 0.57 m            |
| Bulk liquid velocity  | 0.2 cm/s          |
| LDL thickness         | 238 $\mu\text{m}$ |
| Hydraulic radius      | 0.09 m            |



**Fig. S1** The colors of biofilm at days 10 and days 40 respectively.