

# Supplementary Materials: The Fabrication of Ga<sub>2</sub>O<sub>3</sub>/ZSM-5 Hollow Fibers for Efficient Catalytic Conversion of *n*-Butane into Light Olefins and Aromatics

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**Table S1.** The NH<sub>3</sub>-TPD data of the as-prepared catalysts.

| Catalyst                                   | Acid Amount (a.u.) |             |
|--------------------------------------------|--------------------|-------------|
|                                            | Weak Acid          | Strong Acid |
| Nano-ZSM-5                                 | 1740.5             | 566.3       |
| 0.1% Ga <sub>2</sub> O <sub>3</sub> /ZSM-5 | 1603.9             | 435.2       |
| 0.2% Ga <sub>2</sub> O <sub>3</sub> /ZSM-5 | 1615.4             | 300.2       |
| 0.3% Ga <sub>2</sub> O <sub>3</sub> /ZSM-5 | 1697.4             | 507.1       |
| 0.4% Ga <sub>2</sub> O <sub>3</sub> /ZSM-5 | 1788.0             | 500.3       |

**Table S2.** Distribution of products in catalytic conversion of *n*-butane on Nano-ZSM-5.

| Temperature/°C | Conversion/% | Product Yield/% |                               |                               |                                     |     |                                                              |
|----------------|--------------|-----------------|-------------------------------|-------------------------------|-------------------------------------|-----|--------------------------------------------------------------|
|                |              | CH <sub>4</sub> | C <sub>2</sub> H <sub>6</sub> | C <sub>3</sub> H <sub>8</sub> | C <sub>2</sub> = + C <sub>3</sub> = | BTX | C <sub>2</sub> = + C <sub>3</sub> = + C <sub>4</sub> = + BTX |
| 400            | 0.6          | 0.0             | 0.0                           | 0.0                           | 0.1                                 | 0.0 | 0.5                                                          |
| 450            | 1.2          | 0.1             | 0.2                           | 0.1                           | 0.4                                 | 0.0 | 0.8                                                          |
| 500            | 4.1          | 0.4             | 0.6                           | 0.1                           | 1.8                                 | 0.1 | 2.9                                                          |
| 550            | 14.6         | 1.6             | 2.0                           | 0.3                           | 7.2                                 | 0.3 | 10.7                                                         |
| 575            | 25.8         | 2.8             | 3.3                           | 0.5                           | 13.2                                | 0.6 | 19.0                                                         |
| 600            | 42.1         | 4.7             | 5.0                           | 0.9                           | 22.7                                | 1.3 | 31.3                                                         |
| 625            | 60.7         | 7.0             | 6.6                           | 1.3                           | 34.2                                | 2.5 | 45.3                                                         |
| 650            | 77.6         | 9.5             | 7.5                           | 1.7                           | 45.8                                | 4.5 | 58.4                                                         |
| 675            | 90.2         | 12.2            | 7.5                           | 1.7                           | 55.0                                | 7.1 | 68.2                                                         |

**Table S3.** Distribution of products in catalytic conversion of *n*-butane on 0.1% Ga<sub>2</sub>O<sub>3</sub>/ZSM-5.

| Temperature/°C | Conversion/% | Product Yield/% |                               |                               |                                     |      |                                                              |
|----------------|--------------|-----------------|-------------------------------|-------------------------------|-------------------------------------|------|--------------------------------------------------------------|
|                |              | CH <sub>4</sub> | C <sub>2</sub> H <sub>6</sub> | C <sub>3</sub> H <sub>8</sub> | C <sub>2</sub> = + C <sub>3</sub> = | BTX  | C <sub>2</sub> = + C <sub>3</sub> = + C <sub>4</sub> = + BTX |
| 400            | 1.2          | 0.0             | 0.0                           | 0.0                           | 0.1                                 | 0.0  | 0.6                                                          |
| 450            | 1.7          | 0.1             | 0.1                           | 0.1                           | 0.3                                 | 0.1  | 1.2                                                          |
| 500            | 6.5          | 0.3             | 0.4                           | 0.1                           | 2.0                                 | 0.4  | 5.6                                                          |
| 550            | 22.6         | 1.2             | 1.0                           | 0.3                           | 8.7                                 | 2.7  | 19.8                                                         |
| 575            | 33.9         | 1.9             | 1.6                           | 0.4                           | 13.9                                | 4.6  | 29.5                                                         |
| 600            | 47.3         | 2.9             | 2.3                           | 0.5                           | 20.0                                | 7.2  | 40.0                                                         |
| 625            | 59.9         | 4.4             | 3.1                           | 0.7                           | 27.6                                | 9.4  | 50.4                                                         |
| 650            | 74.8         | 6.7             | 4.2                           | 1.0                           | 37.1                                | 12.6 | 61.7                                                         |
| 675            | 88.3         | 9.5             | 5.0                           | 1.4                           | 46.0                                | 14.1 | 69.0                                                         |

**Table S4.** Distribution of products in catalytic conversion of *n*-butane on 0.2% Ga<sub>2</sub>O<sub>3</sub>/ZSM-5.

| Temperature/°C | Conversion/% | Product Yield/% |                               |                               |                                     |      |                                                              |
|----------------|--------------|-----------------|-------------------------------|-------------------------------|-------------------------------------|------|--------------------------------------------------------------|
|                |              | CH <sub>4</sub> | C <sub>2</sub> H <sub>6</sub> | C <sub>3</sub> H <sub>8</sub> | C <sub>2</sub> = + C <sub>3</sub> = | BTX  | C <sub>2</sub> = + C <sub>3</sub> = + C <sub>4</sub> = + BTX |
| 400            | 2.0          | 0.0             | 0.0                           | 0.1                           | 0.2                                 | 0.1  | 1.0                                                          |
| 450            | 3.7          | 0.1             | 0.1                           | 0.1                           | 0.9                                 | 0.2  | 2.7                                                          |
| 500            | 16.2         | 0.7             | 0.5                           | 0.3                           | 6.3                                 | 2.1  | 14.2                                                         |
| 550            | 51.8         | 2.4             | 1.6                           | 1.1                           | 20.4                                | 14.0 | 43.9                                                         |
| 575            | 68.8         | 3.4             | 2.4                           | 1.4                           | 26.6                                | 20.1 | 56.3                                                         |
| 600            | 82.3         | 4.5             | 3.3                           | 1.7                           | 32.1                                | 29.2 | 69.7                                                         |
| 625            | 91.8         | 5.7             | 4.2                           | 1.8                           | 36.4                                | 35.7 | 78.3                                                         |
| 650            | 97.4         | 7.7             | 5.0                           | 1.7                           | 40.6                                | 37.5 | 81.9                                                         |
| 675            | 100.0        | 9.7             | 4.9                           | 1.4                           | 40.7                                | 38.6 | 81.2                                                         |

**Table S5.** Distribution of products in catalytic conversion of *n*-butane on 0.3% Ga<sub>2</sub>O<sub>3</sub>/ZSM-5.

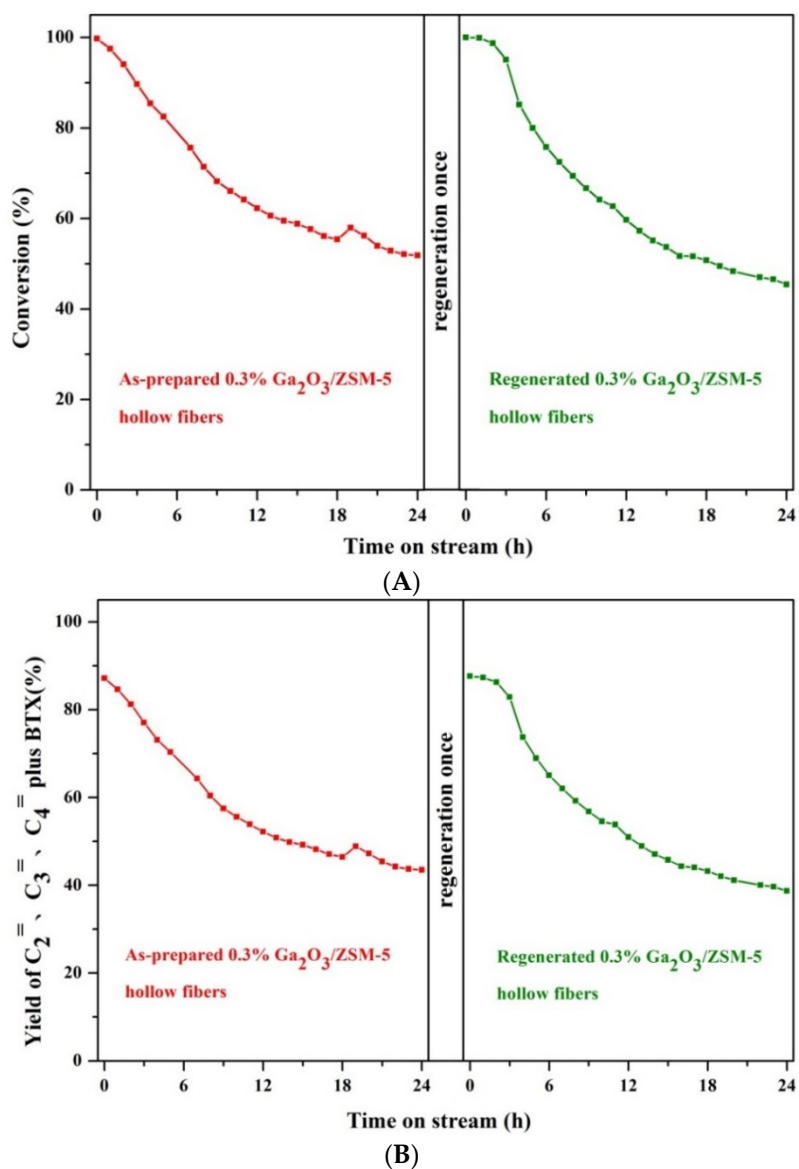
| Temperature/°C | Conversion/% | Product Yield/% |                               |                               |                                     |      |                                                              |
|----------------|--------------|-----------------|-------------------------------|-------------------------------|-------------------------------------|------|--------------------------------------------------------------|
|                |              | CH <sub>4</sub> | C <sub>2</sub> H <sub>6</sub> | C <sub>3</sub> H <sub>8</sub> | C <sub>2</sub> = + C <sub>3</sub> = | BTX  | C <sub>2</sub> = + C <sub>3</sub> = + C <sub>4</sub> = + BTX |
| 400            | 3.0          | 0.0             | 0.0                           | 0.0                           | 0.1                                 | 0.3  | 0.9                                                          |
| 450            | 5.4          | 0.2             | 0.3                           | 0.5                           | 1.4                                 | 0.2  | 4.0                                                          |
| 500            | 26.4         | 1.3             | 0.7                           | 0.7                           | 11.0                                | 5.5  | 22.9                                                         |
| 550            | 68.6         | 3.6             | 1.7                           | 2.0                           | 25.0                                | 25.6 | 57.9                                                         |
| 575            | 84.7         | 4.8             | 2.3                           | 2.5                           | 30.4                                | 34.9 | 71.1                                                         |
| 600            | 93.8         | 5.7             | 2.8                           | 2.5                           | 32.9                                | 37.3 | 74.3                                                         |
| 625            | 98.2         | 6.6             | 3.2                           | 2.1                           | 34.5                                | 44.6 | 81.5                                                         |
| 650            | 99.7         | 7.6             | 3.8                           | 1.6                           | 35.0                                | 45.3 | 81.5                                                         |
| 675            | 100.0        | 10.5            | 4.2                           | 1.1                           | 35.7                                | 40.2 | 76.6                                                         |

**Table S6.** Distribution of products in catalytic conversion of *n*-butane on 0.4% Ga<sub>2</sub>O<sub>3</sub>/ZSM-5.

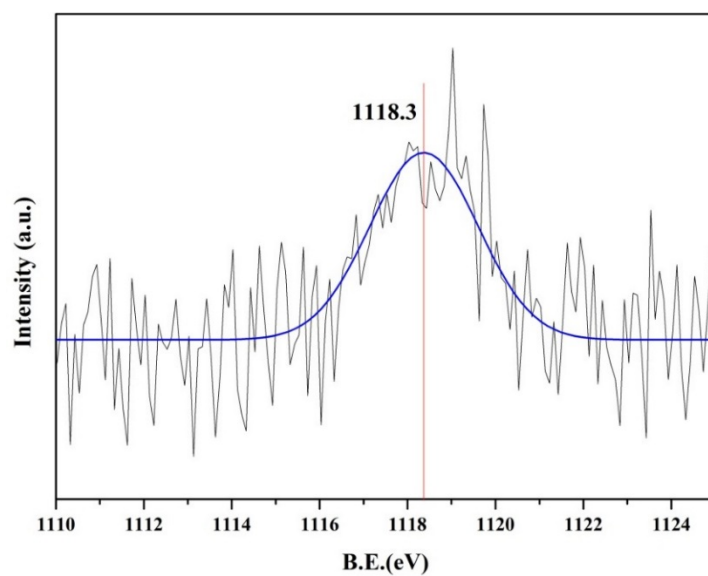
| Temperature/°C | Conversion/% | Product Yield/% |                               |                               |                                     |      |                                                              |
|----------------|--------------|-----------------|-------------------------------|-------------------------------|-------------------------------------|------|--------------------------------------------------------------|
|                |              | CH <sub>4</sub> | C <sub>2</sub> H <sub>6</sub> | C <sub>3</sub> H <sub>8</sub> | C <sub>2</sub> = + C <sub>3</sub> = | BTX  | C <sub>2</sub> = + C <sub>3</sub> = + C <sub>4</sub> = + BTX |
| 400            | 1.6          | 0.0             | 0.0                           | 0.0                           | 0.2                                 | 0.3  | 1.1                                                          |
| 450            | 6.8          | 0.4             | 0.2                           | 0.2                           | 2.6                                 | 0.4  | 5.9                                                          |
| 500            | 31.2         | 1.6             | 0.7                           | 0.8                           | 12.5                                | 6.6  | 25.7                                                         |
| 550            | 78.0         | 4.7             | 1.9                           | 2.6                           | 29.2                                | 29.4 | 65.0                                                         |
| 575            | 90.8         | 5.3             | 2.2                           | 2.7                           | 32.6                                | 37.5 | 74.7                                                         |
| 600            | 96.5         | 5.6             | 2.7                           | 2.4                           | 35.2                                | 40.7 | 79.2                                                         |
| 625            | 99.2         | 6.3             | 3.1                           | 1.9                           | 35.5                                | 42.8 | 80.2                                                         |
| 650            | 100.0        | 7.5             | 3.6                           | 1.4                           | 36.8                                | 43.3 | 81.3                                                         |
| 675            | 99.9         | 9.0             | 4.1                           | 1.0                           | 39.3                                | 35.9 | 76.9                                                         |

**Table S7.** Distribution of products in catalytic conversion of *n*-butane on 0.3% Ga<sub>2</sub>O<sub>3</sub>/ZSM-5 fibers.

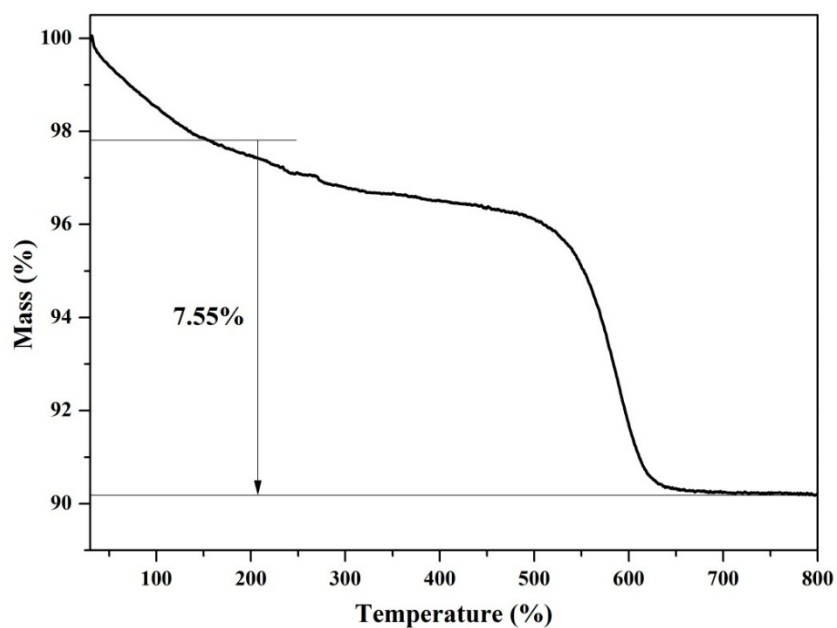
| Temperature/°C | Conversion/% | Product Yield/% |                               |                               |                                     |      |                                                              |
|----------------|--------------|-----------------|-------------------------------|-------------------------------|-------------------------------------|------|--------------------------------------------------------------|
|                |              | CH <sub>4</sub> | C <sub>2</sub> H <sub>6</sub> | C <sub>3</sub> H <sub>8</sub> | C <sub>2</sub> = + C <sub>3</sub> = | BTX  | C <sub>2</sub> = + C <sub>3</sub> = + C <sub>4</sub> = + BTX |
| 400            | 3.3          | 0.1             | 0.1                           | 0.1                           | 0.4                                 | 1.4  | 2.7                                                          |
| 450            | 18.5         | 0.9             | 0.5                           | 0.5                           | 7.4                                 | 2.1  | 13.9                                                         |
| 500            | 65.3         | 3.5             | 1.6                           | 1.9                           | 23.3                                | 25.8 | 55.0                                                         |
| 550            | 95.3         | 5.6             | 3.0                           | 2.9                           | 33.4                                | 45.4 | 81.7                                                         |
| 575            | 99.2         | 5.7             | 3.5                           | 2.4                           | 31.5                                | 51.4 | 84.4                                                         |
| 600            | 99.9         | 6.3             | 3.8                           | 1.7                           | 32.0                                | 54.7 | 87.6                                                         |
| 625            | 100.0        | 7.8             | 4.5                           | 1.2                           | 32.0                                | 50.9 | 83.6                                                         |
| 650            | 100.0        | 10.1            | 4.9                           | 0.8                           | 33.0                                | 44.2 | 77.5                                                         |
| 675            | 100.0        | 13.7            | 5.4                           | 0.4                           | 34.7                                | 40.8 | 75.8                                                         |



**Figure S1.** Conversion of n-butane (A) and the yield of C<sub>2</sub>, C<sub>3</sub>, C<sub>4</sub> plus BTX (B) as a function of time on stream for the as-prepared and regenerated Ga<sub>2</sub>O<sub>3</sub>/ZSM-5 fibers at 600 °C for 24 h, respectively.



**Figure S2.** Ga 2p<sub>3/2</sub> XPS spectra of the Ga<sub>2</sub>O<sub>3</sub>/ZSM-5 fibers after reaction at 600 °C for 24 h.



**Figure S3.** TG profile of the  $\text{Ga}_2\text{O}_3$  /ZSM-5 fibers after reaction at 600 °C for 24 h.



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