# Electronic Supplementary Information

## The 12 principles of green membrane materials and processes for realizing the United Nations' sustainable development goals

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## 1. Survey questions

Possible scores were 1 to 5 for ‘A’ questions with 1 representing not studied at all and 5 representing well studied.

Possible scores were 1 to 5 for ‘B’ questions with 1 representing not important at all and 5 representing very important.

### 1.1. Membrane Material Survey

1A. To what extent greener compounds for membrane fabrication are considered in the literature?

1B. What is the importance of studying greener compounds for membrane fabrication?

2A. To what extent membrane researchers studied the minimization of wastewater generation during membrane fabrication?

2B. What is the importance of studying the minimization of wastewater generation during membrane fabrication?

3A. To what extent membrane researchers studied the use of less hazardous materials during membrane fabrication?

3B. What is the importance of studying the use of less hazardous materials during membrane fabrication?

4A. To what extent membrane researchers studied the minimization of the number of constituents during membrane fabrication?

4B. What is the importance of studying the minimization of the number of constituents during membrane fabrication?

5A. To what extent membrane researchers studied benign surface modifications for membrane fabrication?

5B. What is the importance of studying benign surface modifications for membrane fabrication?

6A. To what extent membrane researchers studied reducing complexity and steps during membrane fabrication?

6B. What is the importance of reducing the complexity and steps during membrane fabrication?

7A. To what extent membrane researchers focused on achieving ambient conditions during membrane fabrication?

7B. What is the importance of achieving ambient conditions during membrane fabrication?

8A. To what extent membrane researchers focused on maximizing raw material utilization during membrane fabrication?

8B. What is the importance of maximizing raw material utilization during membrane fabrication?

9A. To what extent membrane researchers ensured reproducibility during the reporting of membrane fabrication protocols?

9B. What is the importance of ensuring reproducibility during the reporting of membrane fabrication protocols?

10A. To what extent membrane researchers focused on designing and demonstrating robust performance of newly developed membrane materials?

10B. What is the importance of designing and demonstrating robust performance of newly developed membrane materials?

11A. To what extent membrane researchers keep in mind scalability of membrane fabrication protocols when developing and reporting new membrane materials?

11B. What is the importance of keeping in mind scalability of membrane fabrication protocols when developing and reporting new membrane materials?

12A. To what extent researchers study membranes from a cradle-to-grave mindset and consider the end-of-life treatment of membrane materials?

12B. What is the importance of studying membranes from a cradle-to-grave mindset and consider the end-of-life treatment of membrane materials?

### 1.2. Membrane Process Survey

1A. To what extent minimizing processing steps in membrane-related process development are considered in the literature?

1B. What is the importance of minimizing processing steps in membrane-related process development?

2A. To what extent minimizing buffer tanks and auxiliaries in membrane processes are considered in the literature?

2B. What is the importance of minimizing buffer tanks and auxiliaries in membrane processes?

3A. To what extent membrane researchers studied minimizing solvent consumption in membrane processes?

3B. What is the importance of minimizing solvent consumption in membrane-related processes?

4A. To what extent membrane researchers studied the minimization of the number of constituents during membrane fabrication?

4B. What is the importance of minimizing energy consumption in membrane-related processes?

5A. To what extent membrane researchers study high concentrations and try to maximize concentrations during the application of membrane processes?

5B. What is the importance of studying high concentrations and trying to maximize concentrations during the application of membrane processes?

6A. To what extent membrane researchers studied minimizing footprint of membrane-related processes?

6B. What is the importance of minimizing footprint of membrane-related processes?

7A. To what extent membrane researchers focused on designing safer separation processes?

7B. What is the importance of designing safer separation processes?

8A. To what extent membrane researchers focused on monitoring membrane-related processes with process analytical technologies (PAT)?

8B. What is the importance of monitoring membrane-related processes with process analytical technologies (PAT)?

9A. To what extent membrane researchers try to integrate automation in membrane-related processes?

9B. What is the importance of integrating automation in membrane-related processes?

10A. To what extent membrane researchers exploit artificial intelligence for membrane-related process development?

10B. What is the importance of exploiting artificial intelligence for membrane-related process development?

11A. To what extent membrane researchers focused on developing closed-loop systems for improved sustainability during membrane-related process development?

11B. What is the importance of developing closed-loop systems for improved sustainability during membrane-related process development?

12A. To what extent membrane researchers study and employ the use of renewable energy resources during membrane process development?

12B. What is the importance of studying and employing the use of renewable energy resources during membrane process development?

## 2. Survey results

### 2.1. Membrane Material Survey

**Table 1.** Average scores for the survey questions related to membrane materials. Possible scores were 1 to 5 for 'A' questions with 1 representing not studied at all and 5 representing well studied. Possible scores were 1 to 5 for 'B' questions with 1 representing not important at all and 5 representing very important.

| | Survey questions related to *The 12 Principles of Green Membrane Materials* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| A. Extent of study in the literature | **2.83** | **2.09** | **2.81** | **2.18** | **3.34** | **2.69** | **2.88** | **2.26** | **2.45** | **2.99** | **2.46** | **1.97** |
| B. Importance of the topic | **4.17** | **4.22** | **4.47** | **3.55** | **3.83** | **4.31** | **3.80** | **3.87** | **4.87** | **4.74** | **4.60** | **4.09** |

### 2.2. Membrane Process Survey

**Table 2.** Average scores for the survey questions related to membrane processes. Possible scores were 1 to 5 for 'A' questions with 1 representing not studied at all and 5 representing well studied. Possible scores were 1 to 5 for 'B' questions with 1 representing not important at all and 5 representing very important.

| | Survey questions related to *The 12 Principles of Green Membrane Processes* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| A. Extent of study in the literature | **2.73** | **2.05** | **2.53** | **3.05** | **2.49** | **2.45** | **2.39** | **2.14** | **2.06** | **2.13** | **2.36** | **2.48** |
| B. Importance of the topic | **4.36** | **3.53** | **4.19** | **4.53** | **4.03** | **3.98** | **4.31** | **4.03** | **4.05** | **3.89** | **4.03** | **3.66** |

## 3. Survey participation


**Figure 1.** Geographical location of the anonymous survey participants. About 160 survey invitations were sent out and 142 responses were received.