# Supporting Information

## Integrated High-Performance Microcapsule Fire Extinguishing System for Confined Spaces with Real-Time Monitoring and Early Warning Capabilities

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# 1. Supporting Figures

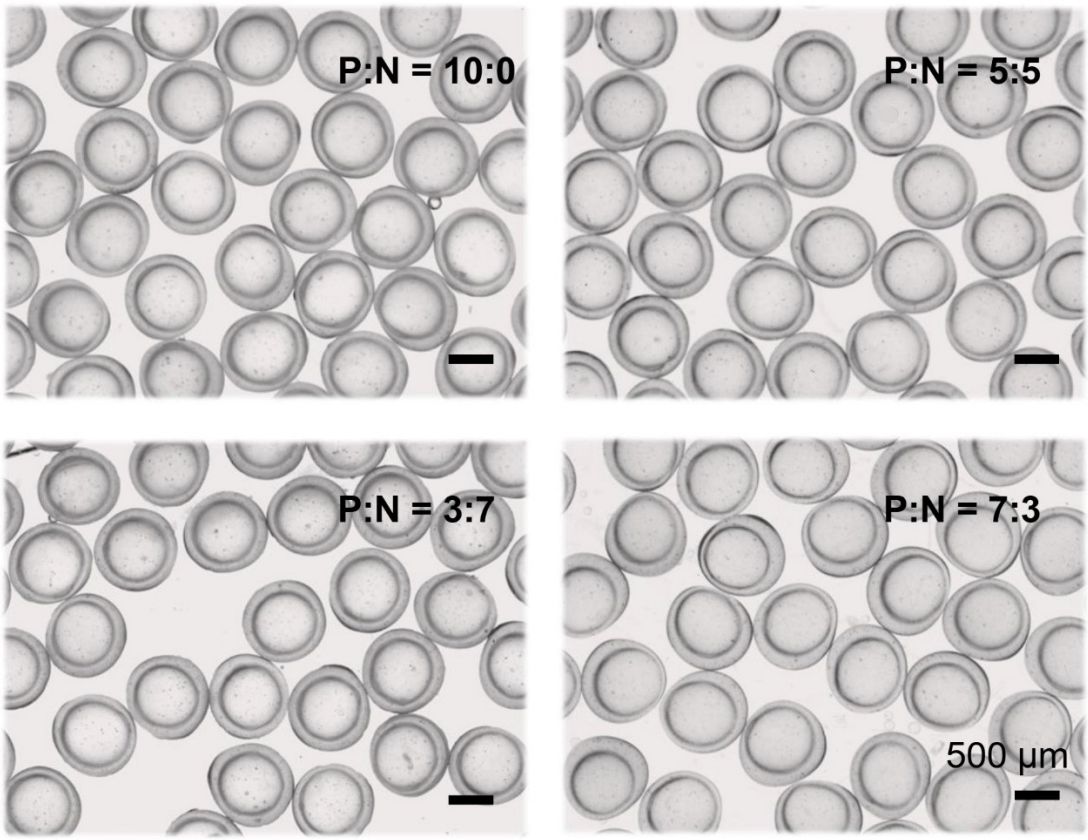


**Fig. S1** Microscopic images of other composite microcapsules.

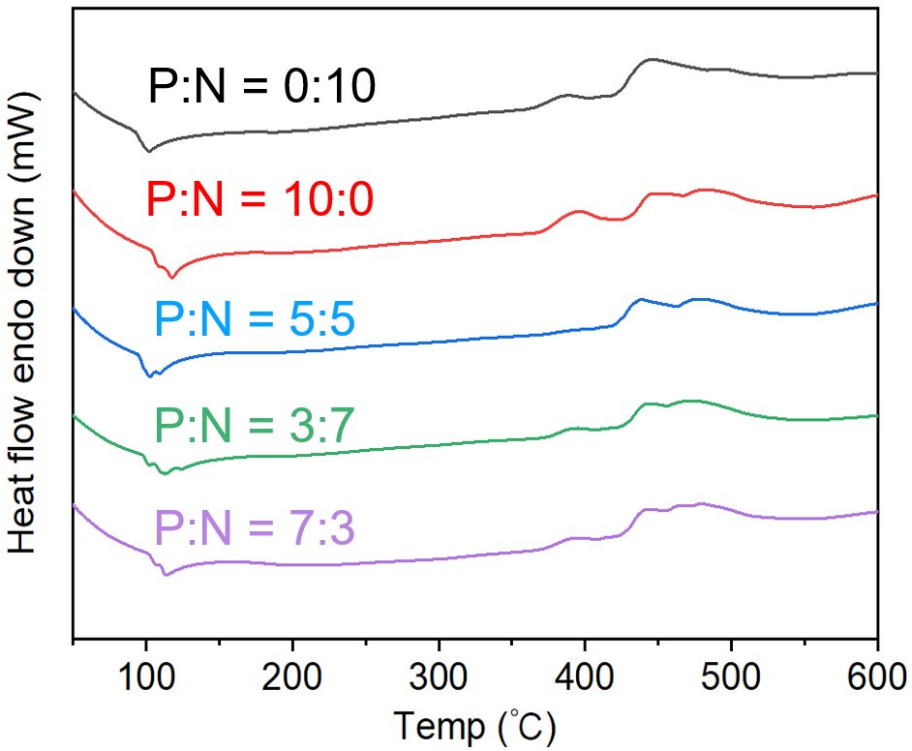


**Fig. S2** DSC curves of composite fire extinguishing microcapsules with different proportions.

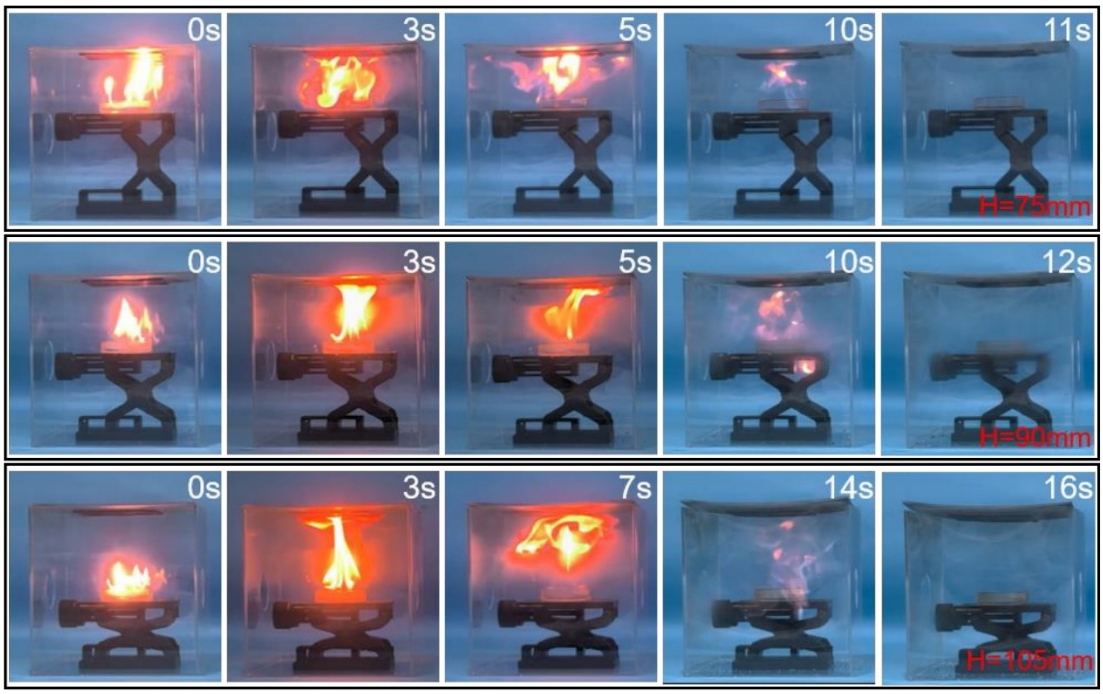


**Fig. S3** Actual images of fire extinguishing patches at different heights.

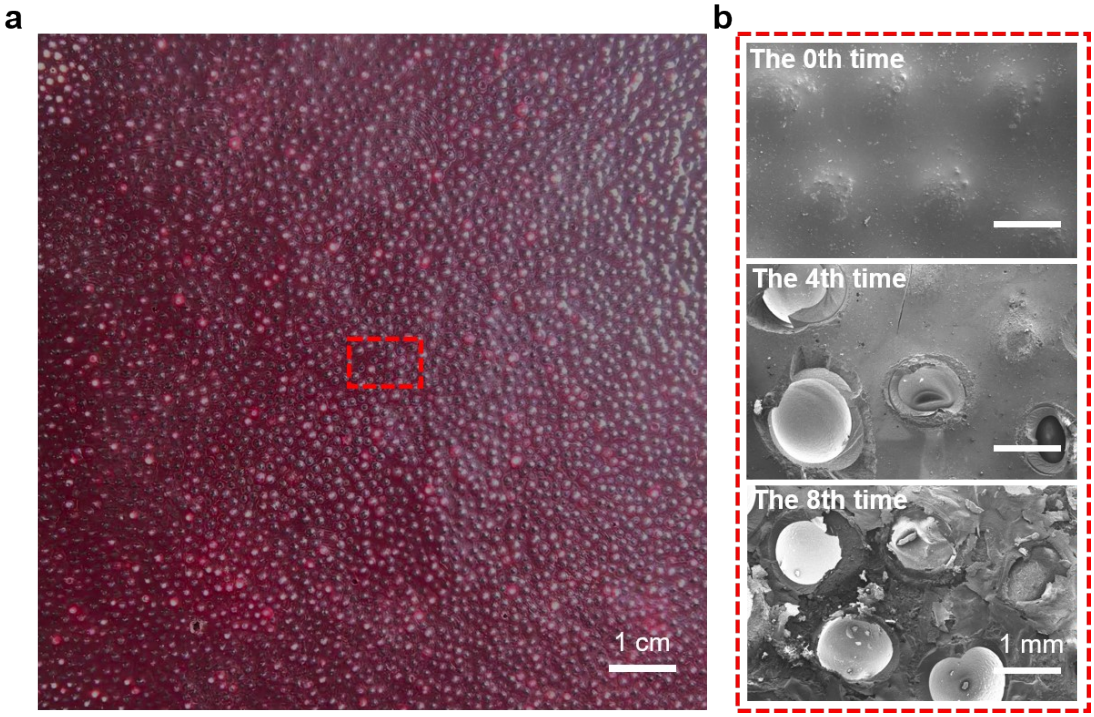


**Fig. S4** SEM images of fire extinguishing patch before and after repeated use. (a) Fire extinguishing patch and central observation area; (b) SEM images of the same central area of the patch after 0, 4, and 8 usage cycles.

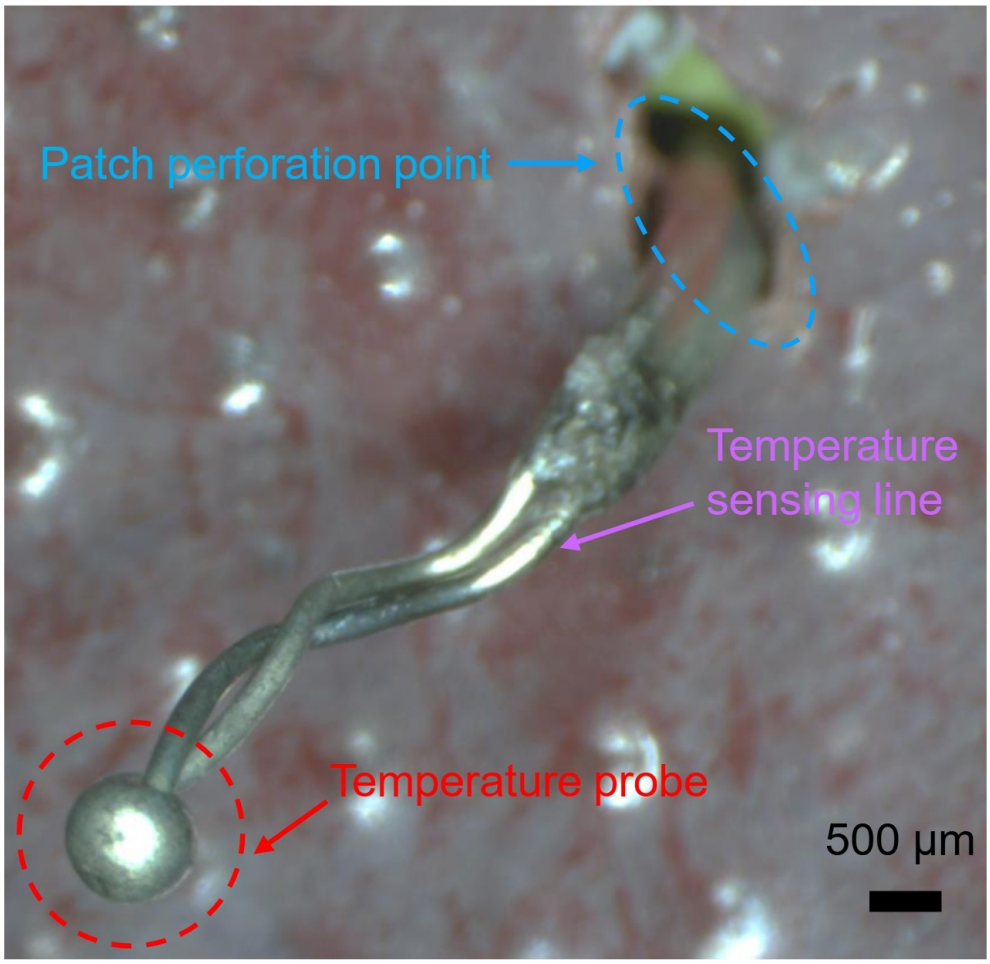


**Fig. S5** Detail diagram of temperature sensing probe for integrated fire extinguishing device.

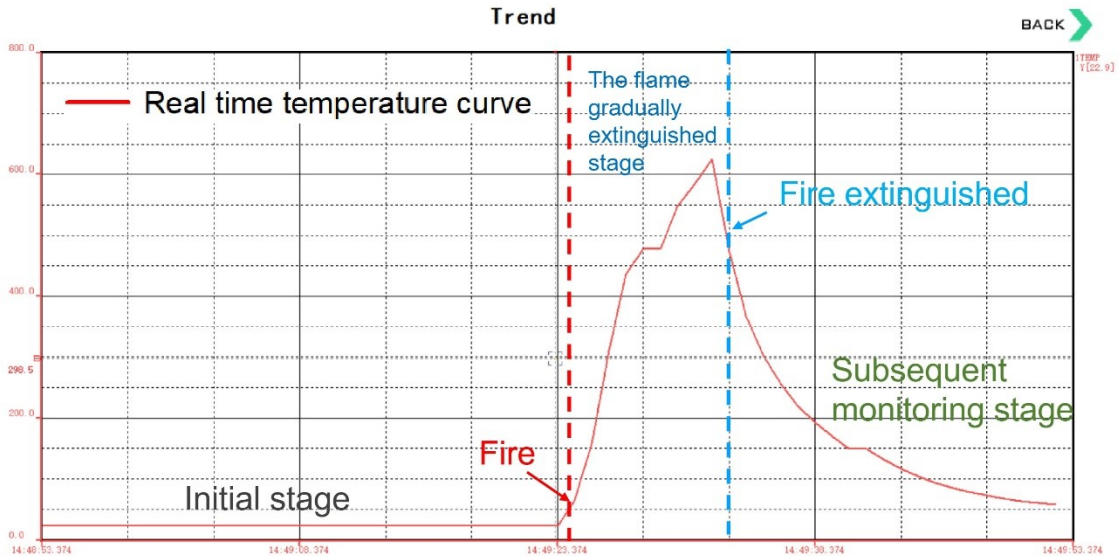


**Fig. S6** Original real-time temperature curve for fire extinguishing application of electric meter box.

**Table. S1** Comparison of co-flow microfluidic technology and other preparation methods

| Preparation method | Shell materials | Core materials | CV value | References |
|---|---|---|---|---|
| Complex coalescence method | Sodium hexametaphosphate and gelatin | perfluorohexanone | ＞5% | 1. |
| Situ polymerization method | Melamine–urea–formaldehyde resin | perfluorohexanone、heptafluorocyclopentane、2-bromo-3,3,3-trifluoropropene） | 5% | 2. |
| Interfacial polymerization method | Polyurea | perfluorohexanone | ＞5% | 3. |
| Emulsification method | Photosensitive resin | perfluorohexanone | ＞5% | 4. |
| Co-flow method | Photosensitive resin | perfluorohexanone /Novec 7100 | 3% | **This study** |

**Table. S2** Brief introduction of technical specifications of temperature sensor in integrated fire extinguishing system.

| Measuring range | Communication distance | Response delay | Measurement accuracy | Transmit power | Measurement interval | Battery capacity |
|---|---|---|---|---|---|---|
| -50℃~1350℃ | 0~1.5 km | ⩽1.5 s | ±0.5 ℃ | ⩽100 mW | 1 s | 8 Ah |

**Table. S3** Computer interface image for temperature alarm

| date | time | name | introduction | value | unit | limiting value | type | level | confirm |
|---|---|---|---|---|---|---|---|---|---|
| 2024/12/18 | 14:49:44 | A1001 | 1TEMP | 157.5 | ℃ | 100.000 | high alarm | emergency | restore |

**Table. S4** Comparison results between this study and other integrated fire extinguishing systems

| Overall size of system | Alarm response time | Response delay from alarm to agent release | Response time of agent release | Reusability | Wireless real-time monitoring | References |
|---|---|---|---|---|---|---|
| Large | - | - | - | No | No | 5. |
| Large | - | - | - | No | No | 6. |
| Medium | ⩽1.5 s | ⩽1.5 s | ⩽1 s | No | Yes | 7. |
| Medium | ~1.5 s | Total time ~1.7 s | | No | Yes | 8. |
| Large | 5.8 ± 0.3 s | - | - | No | Yes | 9. |
| Small | - | - | 0.06 ms | Yes | No | 10. |
| Small | - | - | 0.06 ms | Yes | No | 11. |
| Small | ⩽1.5 s | 0 s | 0.075 ms | Yes | Yes | **This study** |

## References


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## 2. Supporting Movies

**Movie S1** High speed photography captures the complete process of high-performance microcapsule explosion wax extinguishing candle flame.

**Movie S2** The complete process of comparing the fire extinguishing performance of five groups of capsules.

**Movie S3** The complete process of repeatedly extinguishing fires with a fire extinguishing patch.

**Movie S4** Comparison of fire extinguishing performance of fire extinguishing patches for fires in different locations.

**Movie S5** Integrated fire extinguishing device applied to the complete process of actual fire in the electric meter box.