**Supplementary information**

# Microplastic release from the degradation of polypropylene feeding bottles during infant formula preparation

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# Microplastic release from the degradation of polypropylene feeding bottles during infant formula preparation

Dunzhu Li[1,2]†, Yunhong Shi[2]†, Luming Yang[2,1], Liwen Xiao[2,3]*, Daniel K. Kehoe[1], Yurii K. Gun'ko [4,5], John J. Boland[1,4]*, Jing Jing Wang[1]*

[1]AMBER Research Centre and Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN), Trinity College Dublin, D2, Ireland

[2]Department of Civil, Structural and Environmental Engineering, Trinity College Dublin, Dublin 2, Ireland

[3]TrinityHaus, Trinity College Dublin, Dublin 2, Ireland

[4]School of Chemistry, Trinity College Dublin, Dublin 2, Ireland

[5]BEACON, Bioeconomy SFI Research Centre, University College Dublin, Dublin 4, Ireland
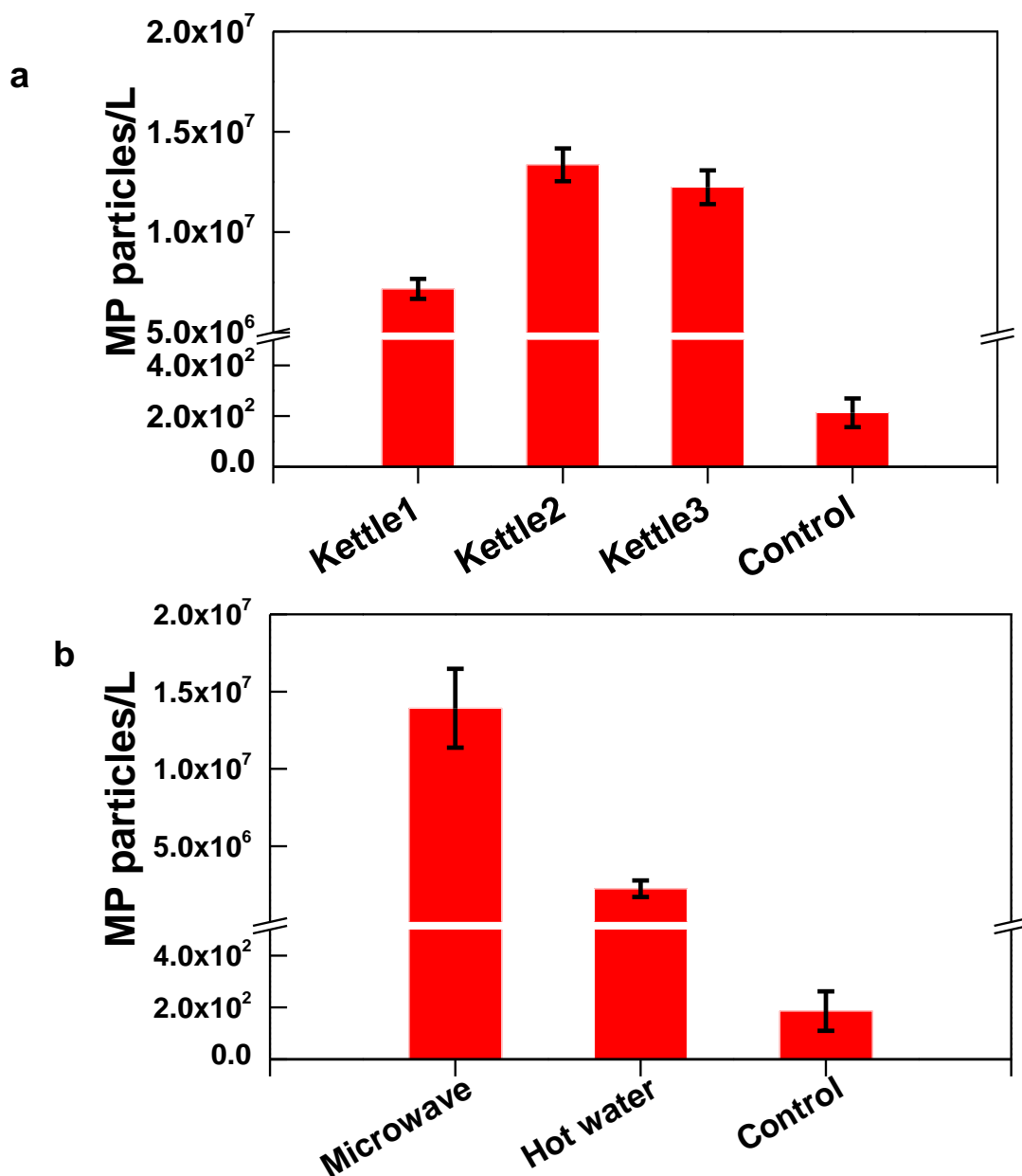
*Correspondence to: Jing Jing Wang, jjwang@tcd.ie; Liwen Xiao, liwen.xiao@tcd.ie; John J. Boland, jboland@tcd.ie

†For equal contributions

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*Supplementary Figures 1 – 8*



**Supplementary Figure 1. (a) The MPs released from new kettles.** 3 representative kettle products from different UK manufacturers. **(b) Comparison of heating methods – in situ microwave heating vs directly adding hot water.** In each case the water temperature and volume were 85 °C and 250 mL, respectively, and a transparent PP lunchbox, designed for microwave and hot food storage, was used in this test. All the error bars in Figs. a and b indicate the standard errors of mean values.
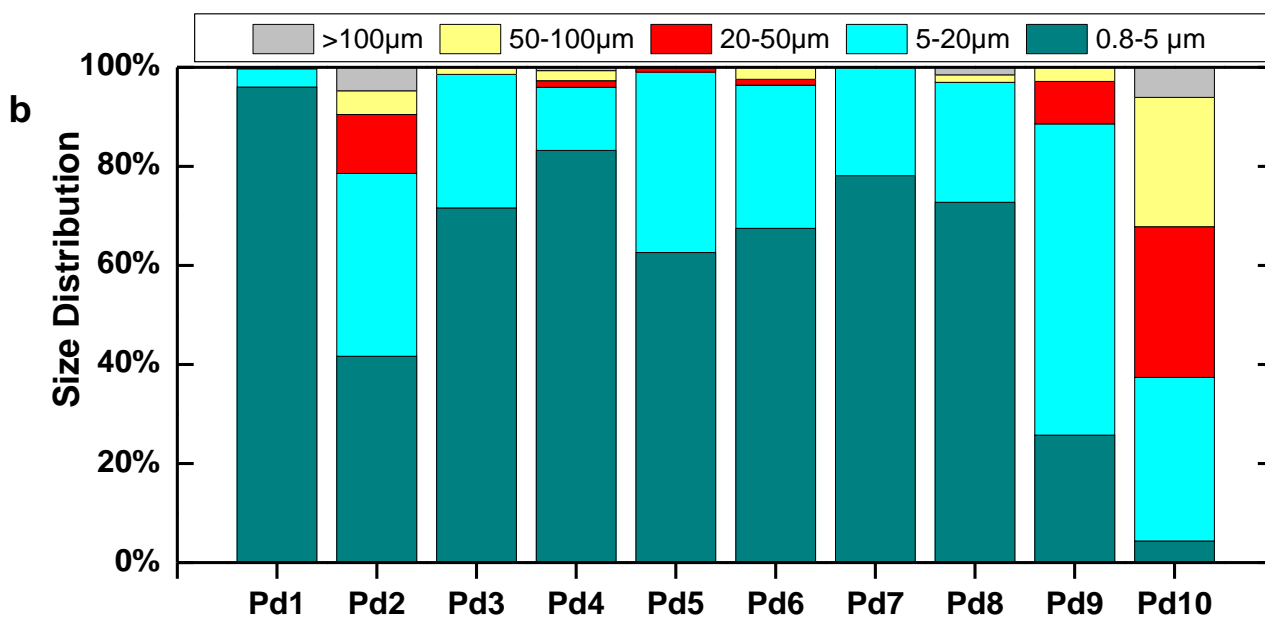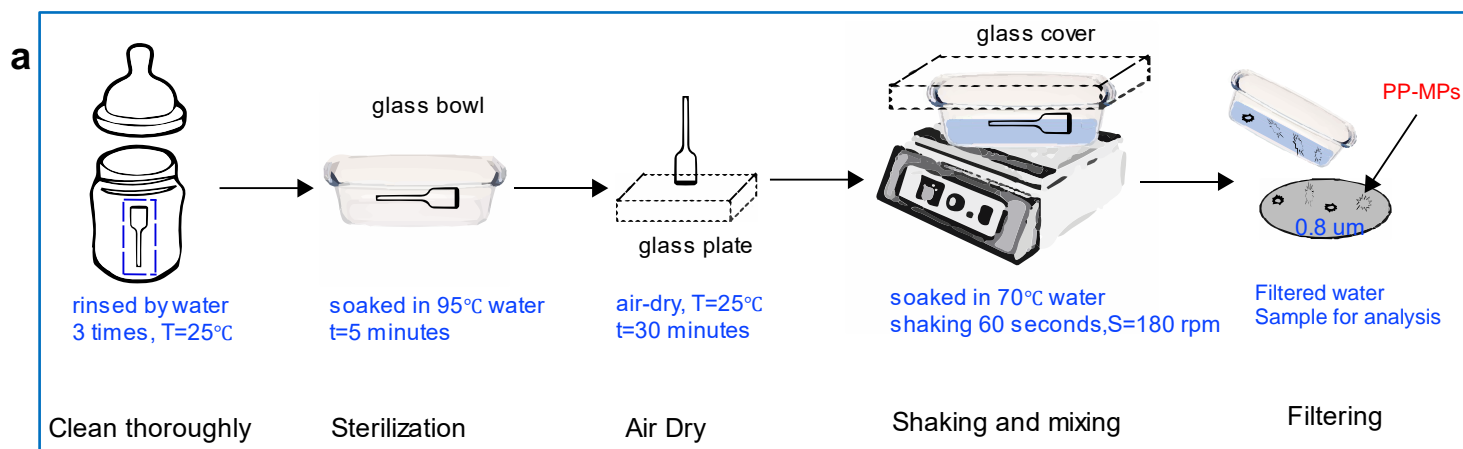
**Supplementary Figure 2. (a) Schematic diagram of the preparation of accessories samples. (b) Size distribution of MPs released from Pd1-10.** Note Pd9 and Pd10 have only PP accessories (gravity ball and round disk)
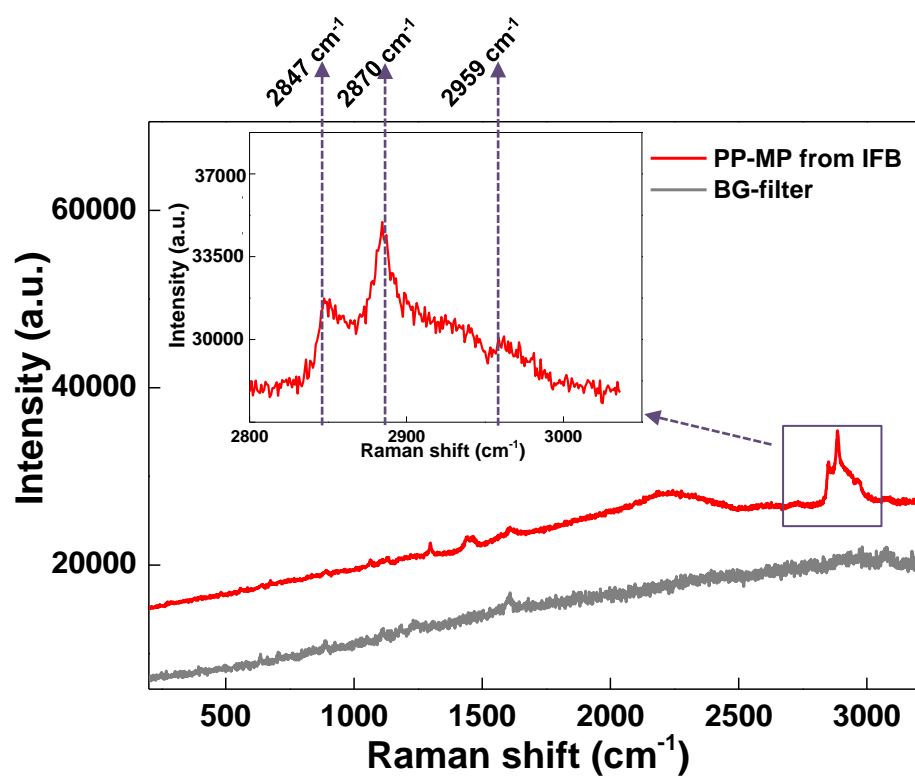
**Supplementary Figure 3. The Raman spectra of PP-MPs and filter background.**
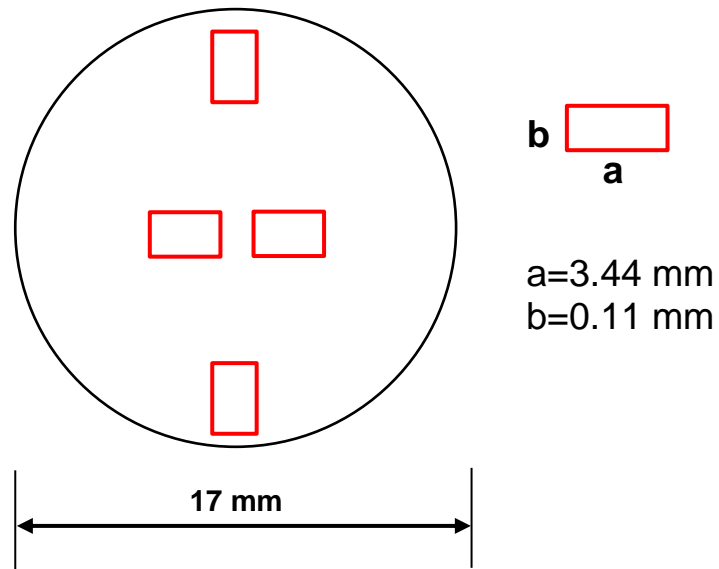
**Supplementary Figure 4. The four analysed spots in the filter membrane.** To symbolise the location, the analysed spots in the filter is exaggerated. The total diameter of filter is 25 mm while only the middle part with diameter of 17 mm was the working area.
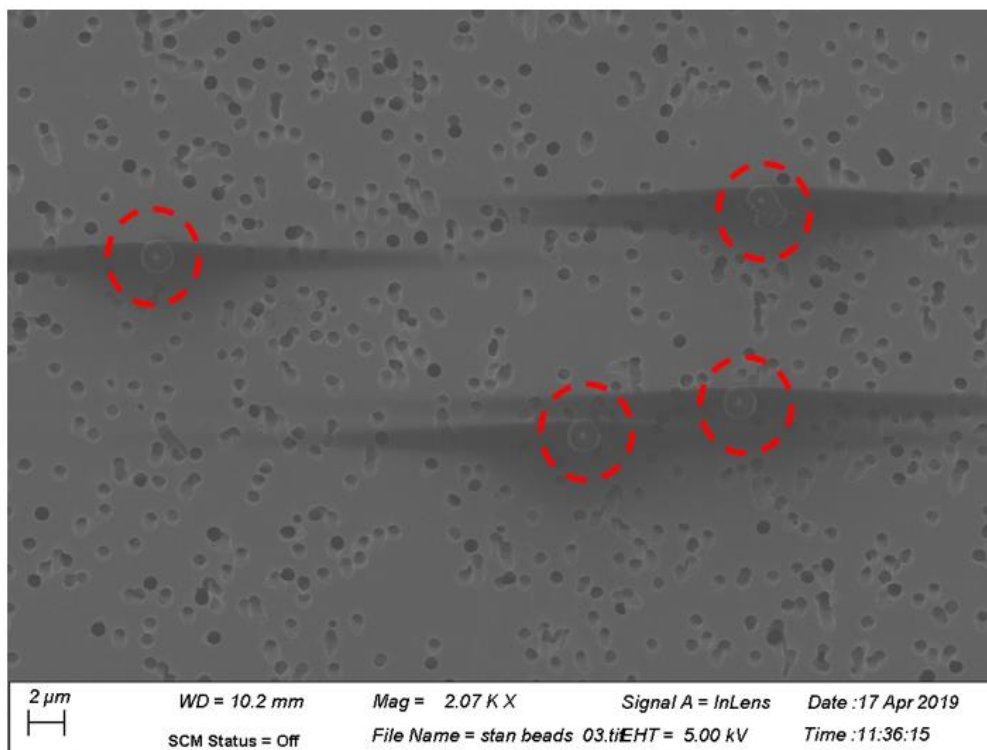
**Supplementary Figure 5. The check of filter surface.** The image was recorded using an SEM system; the particles circled by red circles are PS-MPs.
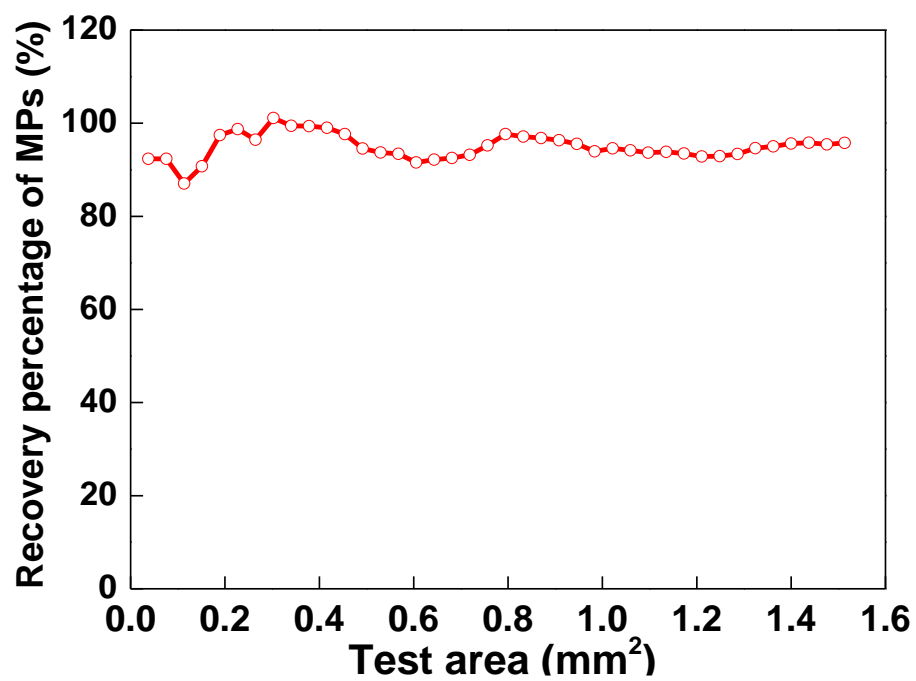
**Supplementary Figure 6. The MPs recovery efficiency with different test area.**

glass petri dish

glass petri dish

glass bowl

glass plate

rinsed 3 ×tap
water T=25℃

soaked in 95℃ tap water
t=5 minutes

rinsed 3× tap water
dried t=30 minutes

70 ℃ formula, shaking 60
seconds,S=180 rpm

poured out formula

poured in 70℃ tap water
shaking 60 seconds,S=180 rpm

Filtered water
Sample for analysis

0.8 um

S1: Clean

S2: Sterilization

S3: Air Dry

S4: Formula shaking and pour out

S5: Water shaking

S6: Filtering

**Supplementary Figure 7. Modified procedure to assess the influence of formula on PP release.** All tap water samples were prefiltered using 0.45 µm syringe filter (Minisart NY, 25mm) to remove any large particles.
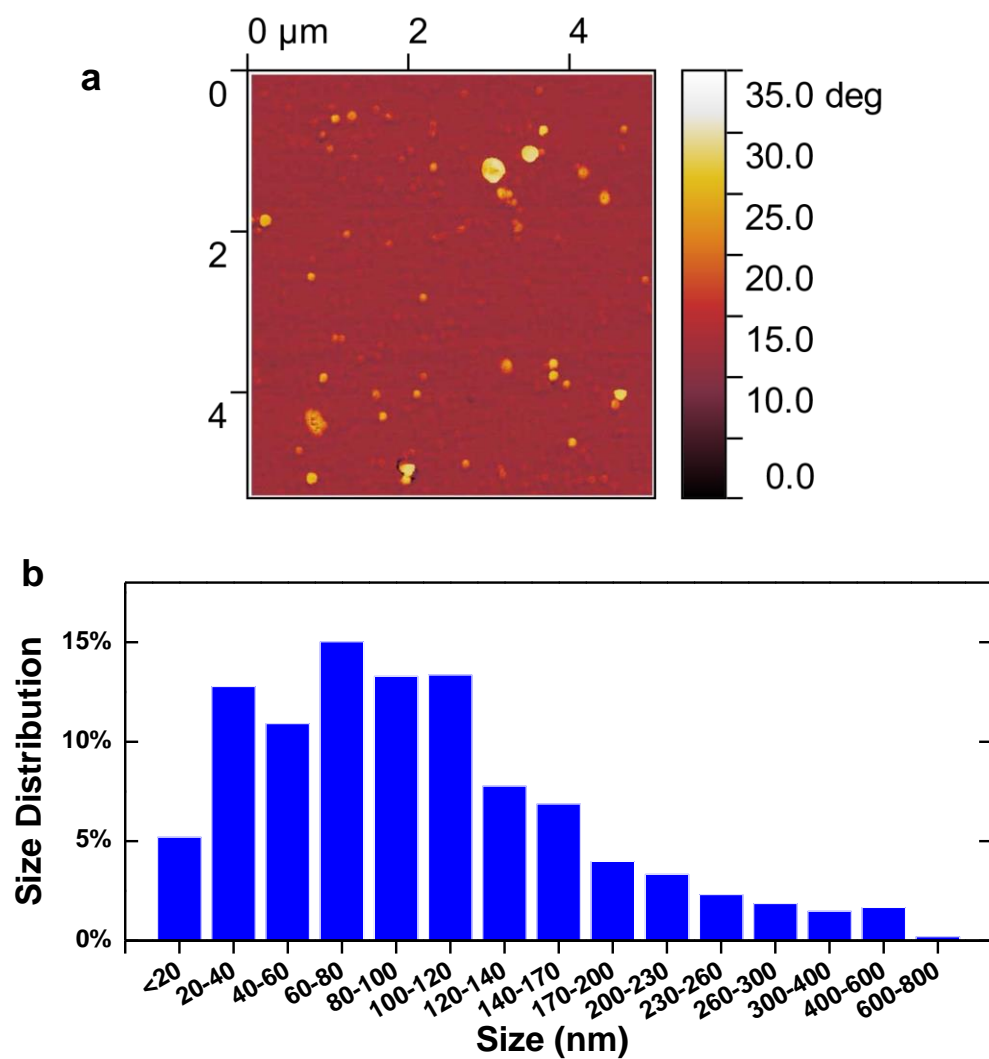
**Supplementary Figure 8. (a) The phase images of Pd1 sample drop-casted on wafer. (b) The size distribution of nano particles released from IFB Pd1.** The Pd1 sample was first diluted 100 times by ultrapure water, which were then drop-casted (10 µL) on the clean silicon wafer (wafer was treated by ethanol in advance).

# Supplementary Tables 1 – 8

**Supplementary Table 1. Summary of the experiment conditions and MPs amount released from IFBs.**

| Product No | Test part | Designed Bottle Volume | Test condition | MPs amount |
|---|---|---|---|---|
| | | mL | | Particles/L |
| Pd1 | Bottle body | 125 | 125 mL-Hot water (70 °C) | 8,254,000 ± 772,000 |
| Pd2 | Bottle body | 260 | 180 mL-Hot water (70 °C) | 11,657,000 ± 1,578,000 |
| Pd3 | Bottle body | 260 | 180 mL-Hot water (70 °C) | 8,925,000 ± 1,948,000 |
| Pd4 | Bottle body | 160 | 125 mL-Hot water (70 °C) | 16,224,000 ± 1,302,000 |
| Pd5 | Bottle body | 150 | 125 mL-Hot water (70 °C) | 1,725,000 ± 150,000 |
| Pd6 | Bottle body | 240 | 180 mL-Hot water (70 °C) | 1,967,000 ± 64,000 |
| Pd7 | Bottle body | 150 | 125 mL-Hot water (70 °C) | 1,314,000 ± 131,000 |
| Pd8 | Bottle body | 240 | 180 mL-Hot water (70 °C) | 7,218,000 ± 315,000 |
| Pd2 | Round disk and straw | 180 | 180 mL-Hot water (70 °C) | 2,532,000 ± 273,000 |
| Pd3 | Round disk and straw | 180 | 180 mL-Hot water (70 °C) | 453,000 ± 42,000 |
| Pd6 | Gravity ball | 180 | 180 mL-Hot water (70 °C) | 114,000 ± 27,000 |
| Pd9 | Gravity ball and round disk | 180 | 180 mL-Hot water (70 °C) | 69,000 ± 9,700 |
| Pd10 | Gravity ball and round disk | 180 | 180 mL-Hot water (70 °C) | 267,000 ± 15,000 |

**Supplementary Table 2. The levels of MPs released from IFBs following exposure to water at different temperatures (3 leading products).**

| Temperature | MPs amount of Pd 1 | MPs amount of Pd 2 | MPs amount of Pd 3 |
|---|---|---|---|
| °C | Particles/L | Particles/L | Particles/L |
| 25 | 625,000± 192,000 | 30,000± 3,400 | 77,000± 6,300 |
| 40 | 3,139,000± 564,000 | 301,000± 31,000 | 1,437,000± 180,000 |
| 70 | 6,130,000± 762,000 | 6,328,000± 774,000 | 5,186,000± 362,000 |
| 95 | 54,712,000± 1,232,000 | 12,515,000± 1,989,000 | 7,127,000± 462,000 |

**Supplementary Table 3. The MPs amount released from IFBs in 21-day use (3 representative products).**

| Date | Pd1 | Pd2 | Pd 3 |
|------|------|------|------|
| Day | Particles/L | Particles/L | Particles/L |
| 1 | 8,254,000± 772,000 | 11,657,000± 1,578,000 | 8,925,000± 1,948,000 |
| 3 | 4,055,000± 406,000 | 5,263,000± 487,000 | 2,115,000± 169,000 |
| 5 | 3,668,000± 167,000 | 4,483,000± 580,000 | 2,499,000± 353,000 |
| 7 | 9,836,000± 325,000 | 11,058,000± 1,169,000 | 6,397,000± 536,000 |
| 10 | 4,144,000± 515,000 | 2,983,000± 176,000 | 1,380,000± 54,000 |
| 14 | 11,060,000± 1,467,000 | 14,502,000± 604,000 | 8,981,000± 528,000 |
| 18 | 6,435,000± 947,000 | 11,266,000± 1,573,000 | 643,000± 104,000 |
| 21 | 4,870,000± 616,000 | 2,265,000± 221,000 | 1,582,000± 158,000 |

**Supplementary Table 4. The indication of *i* and *j* in the assessment.**

| Product | PP used type | PP used in bottle only | PP used in both bottle and accessories | PP used in accessories only |
|---|---|---|---|---|
| | *i* \ *j* | 1 | 2 | 3 |
| Pd1 | 1 | Found-Tested | NF | NF |
| Pd2 | 2 | Found-Tested | Found-Tested | Found-Tested |
| Pd3 | 3 | Found-Tested | Found-Tested | NF |
| Pd4 | 4 | Found-Tested | NF | NF |
| Pd5 | 5 | Found-Tested | NF | NF |
| Pd6 | 6 | Found-Tested | NF | Found-Tested |
| Pd7 | 7 | Found-Tested | NF | NF |
| Pd8 | 8 | Found-Tested | NF | NF |
| Pd9 | 9 | NF | NF | Found-Tested |
| Pd10 | 10 | NF | NF | Found-Tested |

(1) NF=not found in the market; (2) The value used at the assessment of IFBs with different products and pp used types were summarized in Supplementary Tables 6-7.

**Supplementary Table 5. Summary of world market share of IFBs and current infant breastfeeding rate of 12 months babies.**

| Country/Region | Country/Region Code | E-commerce site | IFBs category-% | | | | Breastfeeding Rate (BFR) | |
|---|---|---|---|---|---|---|---|---|
| | | | PP-Bt only | PP-Bt&Ac | PP-Ac only | Others | 12 months | Data Source |
| Argentina | ARG | Mercadolibre.com.ar | 79.1% | 0.0% | 0.0% | 20.9% | 62.0% | 1 |
| Austria | AUS | Amazon.de | 71.6% | 0.0% | 0.0% | 28.4% | 16.0% | 1 |
| Australia | AUT | eBay.com.au | 79.6% | 3.0% | 2.3% | 15.0% | 30.0% | 1 |
| Bangladesh | BGD | Daraz.com.bd | 64.5% | 2.6% | 0.0% | 32.9% | 97.0% | 1 |
| Belgium | BEL | Amazon.fr | 94.6% | 0.0% | 0.0% | 5.4% | 10.0% | 2 |
| Brazil | BRA | Mercadolivre.com.br | 96.9% | 3.1% | 0.0% | 0.0% | 56.0% | 1 |
| Canada | CAN | Amazon.ca | 76.6% | 8.5% | 0.0% | 14.9% | 9.0% | 1 |
| Chile | CHL | Mercadolibre.cl | 55.6% | 0.0% | 0.0% | 44.4% | 21.0% | 1 |
| China, PRC | CHN | Taobao.com | 0.0% | 4.7% | 72.8% | 22.5% | 61.8% | 3 |
| Colombia | COL | Mercadolibre.com.co | 85.0% | 9.0% | 0.0% | 6.1% | 62.0% | 1 |
| Cote d'Ivoire | CIV | Jumia.ci | 75.0% | 0.8% | 0.0% | 24.2% | 92.1% | 1 |
| Denmark | DNK | Amazon.de | 71.6% | 0.0% | 0.0% | 28.4% | 3.0% | 1 |
| Egypt | EGY | Amazon souq.com | 82.6% | 8.7% | 0.0% | 8.7% | 85.5% | 1 |
| France | FRA | Amazon.fr | 94.6% | 0.0% | 0.0% | 5.4% | 9.0% | 1 |
| Germany | DEU | Amazon.de | 71.6% | 0.0% | 0.0% | 28.4% | 23.0% | 1 |
| Hongkong | HKG | Taobao.com | 0.0% | 4.7% | 72.8% | 22.5% | 28.2% | 4 |
| India | IND | Amazon.in | 81.1% | 0.0% | 0.0% | 18.9% | 91.8% | 1 |
| Indonesia | IDN | Tokopedia | 79.6% | 7.7% | 0.0% | 12.7% | 78.0% | 1 |
| Iran | IRN | Digikala | 58.2% | 10.3% | 3.9% | 27.6% | 88.8% | 1 |
| Ireland | IRL | Amazon.uk | 90.5% | 8.2% | 0.0% | 1.3% | 2.0% | 1 |
| Italy | ITA | Amazon.it | 87.9% | 0.0% | 0.0% | 12.1% | 19.0% | 1 |
| Japan | JPN | Amazon.jp | 61.4% | 2.5% | 2.5% | 33.6% | 60.0% | 1 |
| Kenya | KEN | Jumia.co.ke | 86.0% | 14.0% | 0.0% | 0.0% | 89.4% | 1 |
| Malaysia | MYS | Shopee.com.my | 45.0% | 3.2% | 0.5% | 51.3% | 94.7% | 5 |
| Mexico | MEX | Amazon.com.mx | 82.2% | 5.7% | 0.0% | 12.1% | 43.7% | 1 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Morocco | MAR | Jumia.ma | 90.9% | 0.0% | 0.0% | 9.1% | 66.0% | 1 |
| Netherlands | NLD | Bol.com | 50.7% | 49.1% | 0.0% | 0.1% | 11.0% | 1 |
| New Zealand | NZL | eBay.com.au | 79.6% | 3.0% | 2.3% | 15.0% | 44.0% | 1 |
| Nigeria | NGA | Jumia.com.ng | 61.1% | 17.9% | 6.3% | 14.7% | 88.7% | 1 |
| Pakistan | PAK | Daraz.pk | 89.7% | 1.3% | 0.0% | 9.0% | 80.5% | 1 |
| Peru | PER | Mercadolibre.com.pe | 81.7% | 4.8% | 4.0% | 9.5% | 85.3% | 1 |
| Philippines | PHL | Shopee.ph | 65.9% | 0.5% | 1.3% | 32.4% | 61.5% | 1 |
| Poland | POL | Allegro.pl | 95.7% | 1.9% | 0.0% | 2.4% | 17.0% | 6 |
| Portugal | PRT | Amazon.es | 84.0% | 12.1% | 0.0% | 3.9% | 25.9% | 7 |
| Romania | ROU | Emag.ro | 76.7% | 5.0% | 0.0% | 18.3% | 32.0% | 8 |
| Russia | RUS | Wildberrie | 82.8% | 4.3% | 0.0% | 12.9% | 20.0% | 1 |
| Saudi Arabia | SAU | Amazon souq.com | 82.6% | 8.7% | 0.0% | 8.7% | 2.0% | 1 |
| Singapore | SGP | Lazada.sg | 76.4% | 2.0% | 0.0% | 21.7% | 19.0% | 1 |
| South Africa | ZAF | Takealot | 79.2% | 20.8% | 0.0% | 0.0% | 73.7% | 1 |
| South Korea | KOR | 11 street | 6.5% | 12.2% | 25.2% | 56.1% | 46.0% | 1 |
| Spain | ESP | Amazon.es | 84.0% | 12.1% | 0.0% | 3.9% | 23.0% | 1 |
| Switzerland | CHE | Amazon.de | 71.6% | 0.0% | 0.0% | 28.4% | 28.0% | 1 |
| Tunisia | TUN | Jumia.com.tn | 57.6% | 0.0% | 0.0% | 42.4% | 53.7% | 1 |
| Turkey | TUR | Hepsiburada | 58.3% | 2.1% | 4.4% | 35.2% | 74.2% | 1 |
| UAE | ARE | Amazon souq.com | 82.6% | 8.7% | 0.0% | 8.7% | 37.0% | 9 |
| UK | GBR | Amazon.uk | 90.5% | 8.2% | 0.0% | 1.3% | 0.5% | 1 |
| Ukraine | UKR | Rozetka.com.ua | 78.8% | 8.3% | 0.0% | 12.9% | 44.1% | 1 |
| US | USA | Amazon.com | 73.3% | 14.7% | 0.0% | 12.0% | 35.9% | 10 |
| World Average | | | 72.3% | 6.1% | 4.1% | 17.4% | 46.2% | |

(1) Any breastfeeding rate in 12 months was used at the calculation. It includes babies' exclusively, predominantly, fully or partially breastfed. (2) Due to the data availability and survey date, the breastfeeding rate of infants older than 6 months in Romania, 11-month-old infants in China and $\geq$ 12-month-old infants in Portugal was used, respectively. (3) The local leading website was chose based on the sales and popularity ranking of e-commerce business, ranking data from *Statista* (yearly based data,2018) and *SimilarWeb* (monthly based data, May 2019).

**Supplementary Table 6. Summary of different countries' market share of top 10 products of IFBs with different parts made by PP.**

| $P_{i,j}$ | $P_{1,1}$ | $P_{2,1}$ | $P_{2,2}$ | $P_{2,3}$ | $P_{3,1}$ | $P_{3,2}$ | $P_{4,1}$ | $P_{5,1}$ | $P_{6,1}$ | $P_{6,3}$ | $P_{7,1}$ | $P_{8,1}$ | $P_{9,3}$ | $P_{10,3}$ | Total share of PP related IFBs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Country/region | Bottle only | Bottle only | Btl&Acc | Acc only | Bottle only | Btl&Acc | Bottle only | Bottle only | Bottle only | Acc only | Bottle only | Bottle only | Acc only | Acc only | |
| Argentina | 11.20% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 1.21% | 0.00% | 0.00% | 54.59% | 0.00% | 0.00% | 0.00% | 79.1% |
| Austria | 18.35% | 0.00% | 0.00% | 0.00% | 0.43% | 0.00% | 15.30% | 29.13% | 0.00% | 0.00% | 0.00% | 8.00% | 0.00% | 0.00% | 71.6% |
| Australia | 26.05% | 0.00% | 0.04% | 0.00% | 5.35% | 0.00% | 0.85% | 0.00% | 0.00% | 0.00% | 0.00% | 0.08% | 0.00% | 0.00% | 85.0% |
| Bangladesh | 31.58% | 0.00% | 2.63% | 0.00% | 3.95% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 3.95% | 0.00% | 0.00% | 0.00% | 67.1% |
| Belgium | 21.98% | 0.00% | 0.00% | 0.00% | 12.83% | 0.00% | 29.62% | 6.02% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 94.6% |
| Brazil | 94.13% | 0.00% | 3.05% | 0.00% | 0.00% | 0.00% | 0.35% | 0.13% | 0.00% | 0.00% | 0.94% | 0.00% | 0.00% | 0.00% | 100.0% |
| Canada | 14.94% | 0.00% | 0.67% | 0.00% | 17.28% | 0.00% | 6.14% | 3.34% | 0.47% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 85.1% |
| Chile | 0.00% | 5.56% | 0.00% | 0.00% | 5.56% | 0.00% | 5.56% | 27.78% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 55.6% |
| China,PRC | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 20.43% | 7.39% | 77.5% |
| Colombia | 59.79% | 0.00% | 25.82% | 0.00% | 0.00% | 0.00% | 0.00% | 1.75% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 93.9% |
| Cote d'Ivoire | 19.10% | 0.00% | 0.00% | 0.00% | 0.00% | 0.40% | 0.00% | 0.00% | 0.00% | 0.00% | 32.00% | 0.00% | 0.00% | 0.00% | 75.8% |
| Denmark | 18.35% | 0.00% | 0.00% | 0.00% | 0.43% | 0.00% | 15.30% | 29.13% | 0.00% | 0.00% | 0.00% | 8.00% | 0.00% | 0.00% | 71.6% |
| Egypt | 26.09% | 0.00% | 8.70% | 0.00% | 26.09% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 8.70% | 0.00% | 0.00% | 0.00% | 91.3% |
| France | 21.98% | 0.00% | 0.00% | 0.00% | 12.83% | 0.00% | 29.62% | 6.02% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 94.6% |
| Germany | 18.35% | 0.00% | 0.00% | 0.00% | 0.43% | 0.00% | 15.30% | 29.13% | 0.00% | 0.00% | 0.00% | 8.00% | 0.00% | 0.00% | 71.6% |
| Hongkong | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 20.43% | 7.39% | 77.5% |
| India | 56.85% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 2.94% | 0.00% | 0.00% | 0.00% | 81.1% |
| Indonesia | 17.43% | 0.00% | 0.44% | 0.00% | 4.18% | 1.73% | 0.00% | 0.00% | 0.00% | 0.00% | 2.66% | 0.00% | 0.00% | 0.00% | 87.3% |
| Iran | 21.55% | 0.00% | 4.31% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 3.02% | 0.00% | 26.29% | 0.00% | 0.00% | 0.00% | 72.4% |
| Ireland | 3.52% | 0.00% | 0.00% | 0.00% | 38.81% | 8.22% | 15.38% | 14.49% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 98.7% |
| Italy | 19.67% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 44.37% | 2.61% | 0.00% | 0.00% | 19.68% | 0.00% | 0.00% | 0.00% | 87.9% |
| Japan | 17.52% | 0.00% | 1.66% | 0.00% | 0.43% | 0.00% | 2.31% | 36.12% | 0.00% | 0.00% | 0.00% | 4.96% | 0.00% | 0.00% | 66.4% |
| Kenya | 40.00% | 0.00% | 14.00% | 0.00% | 6.00% | 0.00% | 16.00% | 0.00% | 0.00% | 0.00% | 0.00% | 16.00% | 0.00% | 0.00% | 100.0% |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Malaysia | 4.55% | 0.00% | 0.00% | 0.00% | 0.50% | 0.00% | 21.85% | 7.52% | 0.07% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 48.7% |
| Mexico | 31.35% | 0.00% | 5.68% | 0.00% | 0.00% | 0.00% | 5.35% | 5.01% | 0.00% | 0.00% | 5.88% | 0.00% | 0.00% | 0.00% | 87.9% |
| Morocco | 76.36% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 90.9% |
| Netherlands | 31.29% | 0.07% | 40.40% | 0.00% | 2.76% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.15% | 0.00% | 0.00% | 99.9% |
| New Zealand | 26.05% | 0.00% | 0.04% | 0.00% | 5.35% | 0.00% | 0.85% | 0.00% | 0.00% | 0.00% | 0.00% | 0.08% | 0.00% | 0.00% | 85.0% |
| Nigeria | 0.00% | 0.00% | 4.21% | 0.00% | 30.53% | 2.11% | 0.00% | 0.00% | 4.21% | 0.00% | 6.32% | 0.00% | 0.00% | 0.00% | 85.3% |
| Pakistan | 58.33% | 0.00% | 0.00% | 0.00% | 5.77% | 1.28% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 91.0% |
| Peru | 6.35% | 0.00% | 4.76% | 0.00% | 8.73% | 0.00% | 0.00% | 23.02% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 90.5% |
| Philippines | 28.43% | 0.00% | 0.47% | 0.00% | 0.00% | 0.00% | 0.00% | 4.10% | 0.00% | 0.00% | 0.08% | 0.00% | 0.00% | 0.00% | 67.6% |
| Poland | 84.46% | 0.19% | 0.56% | 0.00% | 0.19% | 0.19% | 0.00% | 0.19% | 0.00% | 0.00% | 0.75% | 0.00% | 0.00% | 0.00% | 97.6% |
| Portugal | 18.99% | 0.00% | 7.58% | 0.00% | 15.33% | 3.19% | 9.17% | 2.83% | 0.00% | 0.00% | 3.62% | 0.00% | 0.00% | 0.00% | 96.1% |
| Romania | 62.07% | 0.00% | 0.00% | 0.00% | 12.48% | 3.32% | 0.00% | 0.00% | 0.00% | 0.00% | 0.24% | 1.05% | 0.00% | 0.00% | 81.7% |
| Russia | 4.30% | 0.00% | 0.00% | 0.00% | 14.90% | 1.32% | 0.00% | 0.00% | 0.00% | 0.00% | 16.06% | 0.00% | 0.00% | 0.00% | 87.1% |
| Saudi Arabia | 26.09% | 0.00% | 8.70% | 0.00% | 26.09% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 8.70% | 0.00% | 0.00% | 0.00% | 91.3% |
| Singapore | 56.24% | 0.00% | 1.97% | 0.00% | 4.38% | 0.00% | 3.50% | 3.06% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 78.3% |
| South Africa | 12.77% | 0.00% | 20.07% | 0.00% | 47.45% | 0.36% | 0.00% | 4.74% | 0.00% | 0.00% | 1.46% | 0.00% | 0.00% | 0.00% | 100.0% |
| South Korea | 0.43% | 0.00% | 12.61% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 43.9% |
| Spain | 18.99% | 0.00% | 7.58% | 0.00% | 15.33% | 3.19% | 9.17% | 2.83% | 0.00% | 0.00% | 3.62% | 0.00% | 0.00% | 0.00% | 96.1% |
| Switzerland | 18.35% | 0.00% | 0.00% | 0.00% | 0.43% | 0.00% | 15.30% | 29.13% | 0.00% | 0.00% | 0.00% | 8.00% | 0.00% | 0.00% | 71.6% |
| Tunisia | 3.39% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 6.78% | 0.00% | 30.51% | 0.00% | 0.00% | 0.00% | 57.6% |
| Turkey | 35.82% | 0.00% | 2.13% | 4.43% | 0.00% | 0.00% | 0.00% | 0.82% | 0.00% | 0.00% | 6.97% | 0.00% | 0.00% | 0.00% | 64.8% |
| UAE | 26.09% | 0.00% | 8.70% | 0.00% | 26.09% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 8.70% | 0.00% | 0.00% | 0.00% | 91.3% |
| UK | 3.52% | 0.00% | 0.00% | 0.00% | 38.81% | 8.22% | 15.38% | 14.49% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 98.7% |
| Ukraine | 34.32% | 0.00% | 0.00% | 0.00% | 13.81% | 5.36% | 0.00% | 0.00% | 0.00% | 0.00% | 5.50% | 0.00% | 0.00% | 0.00% | 87.1% |
| US | 18.64% | 8.31% | 12.21% | 0.00% | 3.21% | 1.53% | 4.07% | 11.87% | 0.56% | 0.00% | 0.00% | 6.98% | 0.00% | 0.00% | 88.0% |

(1) $P_{i,j}$ is the same as the equation 3. For example, $P_{1,1}$ = the market share of product 1 with only bottle body made by PP. (2) bottle only = only bottle body made by PP; Acc only = only accessories made by PP; Btl&Acc = both bottle body and accessories made by PP. (3) Data collected in June-August 2019 through e-commerce sites.

**Supplementary Table 7. The amount of IFBs ($A_{ij}$) used the assessment (particles/L).**

| Amount | PP used type | PP used in bottle only | PP used in both bottle and accessories | PP used in accessories only |
|---|---|---|---|---|
| Product | $i$ $\diagdown$ $j$ | 1 | 2 | 3 |
| Pd1 | 1 | 6,520,000 | NF | NF |
| Pd2 | 2 | 7,927,000 | 9,649,000 | 1,722,000 |
| Pd3 | 3 | 4,105,000 | 4,314,000 | NF |
| Pd4 | 4 | 10,384,000 | NF | NF |
| Pd5 | 5 | 1,104,000 | NF | NF |
| Pd6 | 6 | 1,259,000 | NF | 73,000 |
| Pd7 | 7 | 841,000 | NF | NF |
| Pd8 | 8 | 4,619,000 | NF | NF |
| Pd9 | 9 | NF | NF | 45,000 |
| Pd10 | 10 | NF | NF | 171,000 |

(1) The repeated use influence on MPs amount was considered. For example, $A_{1,1}$ = average MPs amount of 21 days. (2) NF = not found in the market.

**Supplementary Table 8. Summary of data used to assess MPs consumption change with the growth of infant.**

| Country | Month | Non-breastfeeding Rate | Feeding volume | MPs daily consumption |
|---|---|---|---|---|
| | | | mL/day | Particles/day |
| US | 1st hour | 0.168 | 90 | 92,749 |
| | 0.2 | 0.176 | 540 | 582,996 |
| | 0.5 | 0.185 | 600 | 680,898 |
| | 0.7 | 0.2 | 680 | 834,253 |
| | 0.9 | 0.207 | 680 | 863,452 |
| | 1 | 0.21 | 760 | 979,021 |
| | 2 | 0.256 | 850 | 1,334,805 |
| | 3 | 0.297 | 900 | 1,639,675 |
| | 4 | 0.353 | 950 | 2,057,109 |
| | 5 | 0.4 | 1000 | 2,453,686 |
| | 6 | 0.424 | 990 | 2,574,898 |
| | 7 | 0.506 | 630 | 1,955,465 |
| | 8 | 0.531 | 630 | 2,052,079 |
| | 9 | 0.565 | 630 | 2,183,473 |
| | 10 | 0.597 | 630 | 2,307,139 |
| | 11 | 0.621 | 630 | 2,399,889 |
| | 12 | 0.641 | 630 | 2,477,180 |
| UK | 1st hour | 0.19 | 90 | 83,655 |
| | 0.07 | 0.24 | 540 | 634,020 |
| | 0.10 | 0.26 | 540 | 686,855 |
| | 0.13 | 0.28 | 540 | 739,690 |
| | 0.17 | 0.29 | 540 | 766,107 |
| | 0.20 | 0.3 | 540 | 792,525 |
| | 0.23 | 0.31 | 570 | 864,439 |
| | 0.47 | 0.34 | 600 | 997,994 |
| | 1.4 | 0.45 | 760 | 1,673,108 |
| | 4 | 0.58 | 950 | 2,695,562 |
| | 6 | 0.66 | 990 | 3,196,516 |
| | 9 | 0.77 | 630 | 2,373,171 |
| | 12 | 0.995 | 630 | 3,066,630 |
| Brazil | 1st hour | 0.583 | 90 | 344,718 |
| | 1 | 0.139 | 760 | 694,035 |
| | 4 | 0.269 | 900 | 1,590,551 |
| | 6 | 0.274 | 990 | 1,782,127 |
| | 7 | 0.39 | 630 | 1,614,202 |
| | 10 | 0.465 | 630 | 1,924,626 |
| | 12 | 0.44 | 630 | 1,821,151 |

| | | | | |
|---|---|---|---|---|
| India | 1st hour | 0.767 | 90 | 430,793 |
| | 1 | 0.038 | 760 | 180,230 |
| | 3 | 0.046 | 900 | 258,364 |
| | 5 | 0.049 | 1000 | 305,793 |
| | 6 | 0.024 | 990 | 148,278 |
| | 7 | 0.062 | 630 | 243,760 |
| | 10 | 0.086 | 630 | 338,119 |
| | 12 | 0.082 | 630 | 322,393 |
| China | 1st hour | 0.887 | 90 | 6,237 |
| | 1 | 0.081 | 760 | 4,809 |
| | 2 | 0.065 | 850 | 4,316 |
| | 3 | 0.082 | 900 | 5,766 |
| | 4 | 0.084 | 950 | 6,234 |
| | 5 | 0.11 | 1000 | 8,594 |
| | 6 | 0.105 | 990 | 8,121 |
| | 7 | 0.135 | 630 | 6,645 |
| | 8 | 0.166 | 630 | 8,170 |
| | 9 | 0.199 | 630 | 9,795 |
| | 10 | 0.272 | 630 | 13,388 |
| | 11 | 0.341 | 630 | 16,784 |
| | 12 | 0.382 | 630 | 18,802 |

Non-Breastfeeding rate were mainly obtained from each countries' report and Lancet paper. US from [1,10]; UK from [1,11]; Brazil from [1,12,13]; India from [1,14]; China from [1,3]; (2) Feeding volume of each month was used the average value from the instructions of the leading formula brands (e.g., Aptamil, Cow&Gate and SMA). (3) 1st hour non-BFR = the percentage without initiation breastfeeding, here we assumed the first meal of infant (90mL) was fed by feeding bottles if the initiation breastfeeding is not conducted.

# Supplementary Notes 1 – 8

## Supplementary Note 1. Precautions to prevent sample contamination

To avoid potential MP contamination, all hardware that came in contact with the samples were made from clean glass. During the sample preparation and test process, particle-free nitrile gloves and laboratory coats (100% cotton) were worn. The sleeves of coats were inserted and fixed inside of the nitrile gloves. Before every work step, the gloves were thoroughly washed by distilled water, followed by deionized (DI) water. All glassware used in the sample filtration and storage (e.g., glass filter holder, glass petri dishes, glass plate, glass bowl and glass beaker) was thoroughly cleaned using 4 steps: detergent (Fairy Original) water wash (step 1, repeat 3 times), distilled water wash (step 2, repeat 3 times), sonication for 30 mins in distilled water (step 3, WiseClean Ultrasound instrument) and finally rinsed with DI water (step 4, repeat 3 times). Afterwards, the clean glassware apparatuses were immediately set up for sample filtration. Gold-coated track etched filters (diameter-25 mm with pore size of 0.8 µm, APC) used for filtration were stored in a special clean dish supplied by the manufacturer. After sample preparation, the filtered samples were stored in a soda lime glass petri dish (Brand[TM], FisherScientific) until tested by Raman for PP-MPs. A blank control sample was analysed with every 10 PP-product samples to determine the background MPs concentration in DI water.

The blank control sample preparation involved the same sample preparation procedure detailed in Supplementary Note 2 except that PP products were replaced by glass beakers (VWR, Borosilicate glass 3.3). 70°C DI water (360 mL) was poured in a thoroughly cleaned glass beaker. The beaker was then shaken at 180 rpm in a reciprocating shaker (60s), finally the water in the beaker was filtered through the gold-coated filter. Based on this procedure, we found a background level of 0-2 MP particles within a 1.7 mm$^2$ area, showing that the protocol developed effectively eliminates MP contamination.

## Supplementary Note 2. Sample preparation

### Supplementary Note 2.1. Processes that must be avoided in sample preparation

Prior to sample preparation, we highlight 3 processes that in our experience must ***be avoided*** due to the potential MP contamination:

(i)      Sonicating of IFBs as part of the cleaning process: sonication is a widely used in laboratories for mixing and cleaning, however we found that sonication can cause the MPs release from PP products within minutes. Hence, sonication was avoided during the cleaning process of all PP products.

(ii)      Heating DI water using plastic kettle: Most plastic kettles are made of PP. Tests involving 3 kettles from different manufacturers in the UK, reveal that the PP kettles release $1.1 \times 10^7$ particles/L during a single boil (Supplementary Figure 1a, carefully following the product instructions at the test). Therefore, plastic kettle was not employed in this study to prepare hot water. Moreover, stainless-steel kettles were not employed to heat water due to the high levels of unknown particles released by the heating process.

(iii)      Directly heating water-filled PP products using a microwave: we found that MPs levels released by direct microwave heating can be one order of magnitude higher than that from pouring hot water at the same temperature (85 °C) directly into PP products, from $2 \times 10^6$ to $14 \times 10^6$ particles/L (Supplementary Figure 1b). The high levels of MPs are likely due to the local overheating of PP products by the microwave.

In this study, DI water was heated in a glass beaker (VWR, Borosilicate glass 3.3) using a microwave oven (Delonghi, 800W). After heating to the desired temperature, we gently shook the beaker to eliminate any temperature gradients due to uneven heating and then poured the hot water into the test PP products to conduct the experiment. Different temperature hot water was obtained by changing the heating time and water volume (e.g., 70°C hot water could be obtained by cooking 360mL DI water in 2.5 mins, with full power). A brand-new microwave was used to avoid any potential contamination due to residues from earlier use. In addition, the beaker was covered by a glass plate to avoid any other potential contamination during the heating process. We found that beakers made of borosilicate glass 3.3 released the lowest level of glass particles (comparing with glass loaf pan, glass bowl and glass bottle). A Raman analysis was able to screen for the presence of glass particles due to their significantly different Raman spectra compared to PP-MPs.

### Supplementary Note 2.2. General sample preparation method

In this study, we investigated MPs release from three pervasively used PP products - plastic lunchboxes, electric plastic kettles and PP-IFBs. In the case of sample preparation of IFBs, all brand-new IFBs were obtained from pharmacy stores and e-commerce sites and were all cleaned thoroughly after removing the packaging. Prior to sample preparation, all the IFBs were cleaned as described in S1 without sonication.

Carefully following the user instructions for the IFBs, sample preparation involved 4 steps (Fig. 2a): (1) Sterilising the bottle body of IFB by a 5-minute soak in hot water (95 °C), which was heated separately using a microwave oven as described in Supplementary Note 2.1. We conducted

this step because sterilisation is a standard cleaning procedure for IFBs, which recommended by WHO[15]; (2) The sterilised bottle was inverted on the clean glass plate using a tweezer and left to dry for 30 mins; (3) 125 or 180 mL (depends on the design volume of the IFBs, Supplementary Table 1) of hot water (70 °C, recommended by WHO) was poured into the dried bottle which was covered by a glass petri dish. The bottle was then placed into a shaking bed (Heidolph, Promax 2020) and shaken with the speed of 180 rpm for 60 seconds to simulate the process of formula preparation. (4) After cooling down to the room temperature, the bottle was gently shaken and filtered through a gold coated polycarbonate membrane filter (diameter-25 mm with pore size of 0.8 µm, Gold-coated track etched filter, APC) which is widely used in MPs studies [16,17].

PP bottles and accessories were tested separately. For the preparation of accessory samples (Pd 2, 3, 6, 9 and 10), we followed a similar sample procedure as used for PP bottle bodies except the step involving shaking and mixing (Supplementary Figure 2a). Instead, the dried accessories were soaked in a glass bowl with 180 ml of hot water (at the requisite temperature) and shaken as described earlier. After cooling down, the accessory was removed and the water filtered.

Testing of each IFBs and accessory product involved five samples (e.g., five brand-new bottles of Pd1 were prepared according to the preparation method as described above). The details of the experiment and the experimental results are summarised in Supplementary Table 1.

Similar to the preparation of IFBs samples, we prepared two other daily-use PP products (lunch box and kettle) by mimicking their most common daily-use scenario. All products were brand new as received from the retailer. For lunchbox sample, we poured 250 ml of 85°C DI water in a thoroughly cleaned lunchbox, and gently shook the cup for 5 mins at the speed of 40 rpm. After cooling to room temperature, we filtered the water samples (Fig. 2a). The temperature chosen for the lunchbox test is similar to that of hot soup and food typically prepared in a lunchbox as well as the daily cleaning temperature inside a dishwasher. In the case of the kettle (1.7 L volume), we poured 800 mL of DI water (room temperature) in the kettle and switched it on. After boiling (kettle automatically switched off) and cooled, we filtered the kettle water sample using the same method employed in the lunchbox.

During these tests, control samples were also performed to confirm that the tested PP products are the sources of such high level of PP-MPs. The procedures of the control sample preparation are similar as described in Supplementary Note 1.

## Supplementary Note 2.3. Sample preparation method for the study of temperature and sterilisation influence on MPs release

To investigate the temperature influence on PP-MPs release, IFBs from three representative products with 40.2% of the world PP-BFP market, were filled each with water at various temperatures and tested. During the preparation of these samples, the sterilisation step (Fig. 2a) was not conducted to avoid interference due to the boiling water. In general, for each product, 4 sets of IFBs (5 IFBs in each set) were thoroughly cleaned by detergent water, distilled water and DI water. After the drying process, these four sets of IFBs were filled with water at room temperature (25 ±2 °C), 40, 70, 95 °C, respectively. Afterwards, the samples were prepared according to step 3 and 4, tested and the results are shown at Supplementary Table 2. We then compared these results to the behaviour of the same samples following sterilisation as described in Supplementary Note 2.2.

**Supplementary Note 2.4. Sample preparation method for the study of repeated use influence on MPs release**

To investigate the effect of repeated use on PP-MPs release, the 3 representative products were used in a 21-day test. One set of each product (each comprised of 5 IFBs) was prepared. For each bottle, to simulate the daily use of IFBs, after sterilisation (1 times/day, step 1), the bottle was filled with 70°C water, shaken, cooled down and poured out for each of the 5 samples (step 2-4, 5 times/day, with 2 hours between each formula preparation step). Samples were measured on days 1, 3, 5, 7, 10, 14, 18 and 21. The results are shown at Supplementary Table 3. Please note that only the IFBs bottle bodies of Pd1-3 were used at the study of temperature, sterilisation and repeated use influence on MPs release.

## Supplementary Note 3. Identification and quantification of PP-MPs by Raman spectroscopy

Raman spectroscopy was used to identify the presence of MPs. A typical Raman spectrum of PP-MPs from a PP-IFBs is shown in Supplementary Figure 3. Consistent with previous publications [18-20], the main active group vibrations of PP are clearly observed. The size and surface area of the determined PP-MPs were measured by the software of ImageJ (US National Institutes of Health, Bethesda, Maryland, USA). Referring to previous studies [17,21], the determined particles were classified into 5 groups in terms of the size: 0.8-5 µm, 5-20 µm, 20-50 µm, 50-100 µm and > 100 µm. A more detailed size distribution is provided in Figure 3a in the main text for BFP-Pd1.

To test the MPs more effectively, four representative spots (2 spots in the middle area and 2 close to the edge of the filter with a total tested area of 1.5136 mm$^2$) rather than the whole filter surface were analysed (Supplementary Figure 4), as detailed in previous studies [21,22]. Each spot consisted of 40 smaller microscope fields of view (110 µm × 86 µm). Each microscope field of view was recorded by an *in-situ* camera (Behold TV, S-VHS) using a 100× objective. For some samples with high particles numbers, the number of test area in four spots were decreased accordingly. Finally, the MPs level (particles/L) in the water sample was determined by equations S1 and S2.

$$A_s = \frac{N_t \times \frac{S_f}{S_t}}{V_f} - A_{ctl} \tag{S1}$$

$$A_{ctl} = \frac{N_{t-ctl} \times \frac{S_f}{S_{t-ctl}}}{V_{f-ctl}} \tag{S2}$$

$A_s$ is the MPs amount in the water sample, particles/L;

$N_t$ is the number of determined MPs in analysed areas, number of particles;

$S_t$ is the total analysed area of the filter membrane, in this study it is 1.5136 mm$^2$;

$S_f$ is the filtered area of the filter membrane, in this study it is 227 mm$^2$;

$V_f$ is the volume of filtered water samples, L;

$A_{ctl}$ is the MPs amount of control sample (all the procedures were the same to tested sample except the IFBs were changed to glass beaker), it can be calculated by equation S2, particles/L;

$N_{t-ctl}$ is the number of determined MPs in analysed area of control samples, particles;

$S_{t-ctl}$ is the total analysed area of the filter, in this study it is 1.5136 mm$^2$;

$V_{f-ctl}$ is the filtered volume of control samples, L.

## Supplementary Note 4. Validation of the method of sample preparation and analysis

We understand the potential uncertainty of the partial analysis method employed in this study (***Supplementary Notes 1-3***), which was also mentioned in previous studies [17,22]. However, analysing particles over the entire area of the filter is not practical given the number of samples involved in this study. In order to assess the reliability of the protocol used, we first employed a standard Polystyrene microplastic (PS-MPs, 64050-15, Polysciences) sample with a particle diameter of 2.0±0.1µm and a concentration of 4,500,000 particles/L. Both the size and concentration are similar to the MPs released from PP products. Before the test, the filter membrane was checked by SEM to assure the smoothness of the surface and the accuracy of the pore size (Supplementary Figure 5). Afterwards, 40 mL of standard PS-MPs suspension was shaken and filtered through the gold-coated filter, which was fixed by a glass filter holder (Ningke, Boro 3.3, diameter-25mm of filter holder, 250 mL of filtered vessel). Due to the smooth surface, accurate pore size and good contrast, and employing the four-region method described in Supplementary Figure 4a PS-MPs recovery efficiency of 94.9±0.4% was established. This recovery rate is competitive with a previous study on MPs [23]. Due to the relatively large numbers of MPs, the recovery was always higher than 87.0% even when the analysed area was comprised of only 4 spots (equal to 0.04 mm$^2$) (see Supplementary Figures 5-6). In terms of the MPs size, the average diameter determined by ImageJ was 2.04±0.08 µm, in good agreement with the known size (2.0±0.1µm). Hence, the sample preparation and analysis methods used here provide a reliable lower-bound estimate of the quantity of MPs released.

## Supplementary Note 5. Control experiment to check the influence of infant formula, tap water and DI water on PP release from IFBs

During daily use the PP products tested in this study necessarily come in contact with infant formula and/or tap water, which may affect PP-MPs release. In this study, control experiments were conducted to test the impact of using tap-water, DI water and infant formula on PP-MP release from IFBs.

### Supplementary Note 5.1. Comparison of MPs release from IFBs using tap water and DI water

The DI water sample was prepared using the method described in Fig. 2a and Supplementary Note 2.2. The same method was also used to prepared tap-water samples except DI was replaced by tap water (obtained from Trinity College Dublin campus, all tap water were prefiltered using 0.45 µm syringe filter (Minisart NY, 25mm) to remove any large particles). Similarly, two-sample student's *t*-test was conducted (OriginPro 8.6) to compare significance of PP-MPs results and a P value <0.05 was assumed to be significant. We found that the PP amounts obtained by using DI water have no significant difference from that using tap water (Fig. 2g, P values obtained using Pd 1 and 2 were 0.13 and 0.18, respectively, both of which are higher than 0.05).

### Supplementary Note 5.2. Comparison of MPs release from IFBs using infant formula and DI water

When testing MPs release from IFBs using infant formula, we found that the presence of large quantities of formula particles significantly interfered the test. Rather, we assessed whether the presence of formula affects the release of PP-MPs particles due to for example the formation of a passivating film on the inner surface of IFBs (Supplementary Figure 7).

For sample preparation using formula, the brand-new IFB Pd1 and Pd2 (5 sample of each product) were cleaned, sterilised and air dried as described in Figure 2a and Supplementary Note 2.2. After air drying, 70°C formula (Aptamil, prepared according to user instruction using prefiltered tap water) was prepared in the IFBs, then mechanically shaken for 60s (180 rpm in a reciprocating shaker). We poured out the formula and kept the formula residue in IFBs to a minimum but formula still coated the interior surface of the bottle. After that, 70°C pre-filtered tap water (125 ml for Pd1 and 180 ml for Pd2) was poured in the IFBs and the mechanical shaking was repeated (180 rpm, 60s). After cooldown, we filtered the water samples through the gold-coated filter (pore size of 0.8 µm) to determine the quantity of MPs released using Raman imaging (see Supplementary Notes 2 and 3). Raman analysis was able to screen for the presence of formula particles due to their significantly different Raman spectra compared to PP-MPs (Fig. 2h). For sample preparation using DI water, we followed the same procedure in Supplementary Figure 7, except only DI water was used.

A two-sample student's *t*-test was also conducted to compare significance of PP-MPs release from formula and DI water prepared samples, respectively. We found that the MP amounts obtained by using DI water have no significant difference from that using formula, regardless of the product used (Fig. 2i, P values obtained using Pd 1 and 2 were 0.89 and 0.96, respectively, both of which are higher than 0.05). These results indicate that formula does not form a protective film on the inner surface of IFBs' that prevents MP release. These results also confirm that using DI water, tap water or formula doesn't affect the MPs release from PP products significantly. Hence, DI water was used throughout this study to reduce the usage of filter papers and to simplify sample preparation.

**Supplementary Note 6. The study of 3 dimensional structure of MPs via Atomic Force Microscope (AFM)**

To obtain three-dimensional topography of PP-MPs, an NT-MDT atomic force microscope (AFM, operating with a Nova NT-MDT SPM software) was employed. Prior to testing, 2-3 drops of the water sample from IFBs were dropped and dried on the surface of a clean silica wafer. Then the sample was tested with a tapping mode probe (Nanosensors, PPP-NCST). The optimal instrument settings are as following: the tuning frequency is ~160KHz; the scan line is 512 pixels, the scan rate is 1 Hz and the scan size is 10-50 µm.

After testing, the data was analysed by the Gwyddion 2.54 software. For each particle, the 3D structures were obtained by *3D view* software. Particle dimensions and average heights were estimated using the *Profiles* analysis. Typical topography maps of PP-MPs were shown in Figure 3 c-k. We found that most of the MPs released from IFBs have lateral size of 0.8-5 µm, with an average thickness of ~0.2 µm. For MPs of larger size of 5-10 µm, the average thickness increased to ~0.3 µm, while MPs of around 20 µm were thickest, with average height of ~2.9 µm. In general, the MPs have a thin flake morphology with the thickness around a tenth of the lateral size.

**Supplementary Note 7. Assessment of MP exposure due to PP-IFB use worldwide**

For each country, the infants' MP exposure assessment was conducted according to equations 1-3 in main text-Methods section. The relevant parameters indication and calculation method are showed below.

$MP_i$ is the MPs exposure of $i$-month-old infants in each country/region, in particles/day;

$BFR_i$ is **any** breastfeeding rate of $i$-month-old infants in each country/region, %, obtained from the Lancet and relevant government reports or publications;

$V_i$ is the daily milk consumption volume of $i$-month-old infants, in mL/day, obtained from the infants' feeding instructions of the world leading formula brands (Aptamil, Cow&Gate and SMA, average volume used). The value is 630 ml per day for 12-month-old infants while other values see Supplementary Table 8;

$P_{PP}$ is the market share of PP related IFBs, which includes PP used in bottle only, accessories only and both bottle and accessories, obtained from data mining of local leading e-commerce sites in each country;

$A_{avg}$, is the **overall average** MPs amount released from PP related IFBs in each country, it is determined by combining the MPs amount and market share of each product in the country. The specific calculation method is shown in equations 1-2;

$P_{Pd10}$ is the market share of representative top 10 PP-IFB products, which includes PP used in bottle only, accessories only and both bottle and accessories, obtained from data mining of local leading e-commerce sites in each country.

Index $i$ refers to the products (Pd 1 to Pd 10), whereas the index $j$ refers to the PP form factor ($j$=1 bottle only; $j$=2 both bottle and accessories; $j$=3 accessories only). For example, $A_{11}$ is the quantity of MPs released from the PP bottle ($j$=1) from Pd 1 ($i$=1). In addition, the influence of repeatedly use on MPs release was also taken into consideration. The 21-day average value was used to indicate the influence on PP-MPs release. Similarly, $P_{11}$ is the market share of product 1 with PP bottle body only. The data $A_{ij}$ were obtained by experiment while $P_{ij}$ were obtained from data mining of local leading e-commerce. The relevant parameter used in the assessment were summarised in Supplementary Tables 5-7.

## Supplementary Note 8. Study of nano particles releasing from PP products

It is well known that plastics break down not only into micro-sized particles but also nano-sized particles [24,25]. Due to 0.8 µm pore size of the filter used in this study, particles less than 800 nm (nano particles, NPs) fall outside of the test range. It is a challenge to accurately quantify the level of NPs (<0.8 µm) due to the tendency of these smaller particles to aggregate in water.

To obtain a lower bound estimate of the NP released from Pd1 of PP-IFB, the sample preparation method was modified. The NPs samples from Pd1 and the corresponding control sample involved the same sample preparation procedure described in Supplementary Note 2 except that DI water were replaced by ultrapure water and in addition the APC filter was replaced by clean silicon wafer (step 4 at Supplementary Note 2.2). The wafer was pre-treated by ethanol to effectively control the aggregation of NPs [24]. During the test, 10 µL of the 100-times diluted water sample from Pd1 was drop-casted onto the wafer. After drying, the sample was tested by AFM (the same one in Supplementary Note 6) in the middle and edge locations (similar to Supplementary Figure 4). Supplementary Figure 8a clearly show that the aggregation was effectively controlled by diluting the raw sample 100 times and drop-casting sample on ethanol treated wafer.

To obtain the quantity of NPs, the total particles number in 40 AFM images for each sample was first counted using software ImageJ. Then the number of particles per unit area ($mm^2$) was determined by calculating the total area of 40 AFM images. The total number of particles contained per liter of raw sample was determined as the number of particles per $mm^2$, the surface coverage of dried sample and the dilution factor. Following the same procedure, the NPs level of the control sample (PP-IFB replaced by glass beaker, see Supplementary Note 2) was also determined. Assuming the control provides a background level of NPs that is always present we deduced the NPs level from the IFB by subtracting this background level from the levels recorded on the IFB sample. In the case of Pd1 exposed to 70°C water, we found NPs level reached $7.01 \pm 0.97$ trillion particles per liter while the NPs in control sample was only around 5% ($0.33 \pm 0.04$ trillion particles/L). This result confirms that Pd1 is the major source of NPs. Supplementary Figure 8b shows the size distribution of the NPs released from Pd1 has a mean particle size of approximately 100 nm.

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