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Nanoplásticos en el medio ambiente: fuentes, destino y efectos

Dr. Francisco Javier Bayo Bernal
Departamento de Ingeniería Química y Ambiental.
Área de Tecnologías del Medio Ambiente

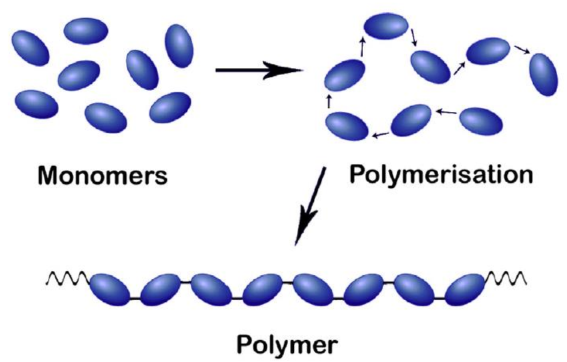
CONAMA 2018

Madrid, 27 de noviembre de 2018

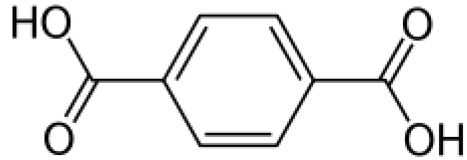
Parkesina
(Royal Society of Arts, Londres, 1862)

Plastikos – *Plasticus* → Susceptible de ser moldeado

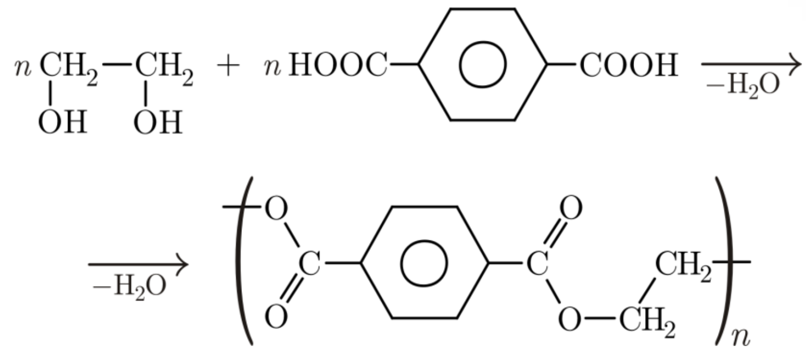
Macromoléculas

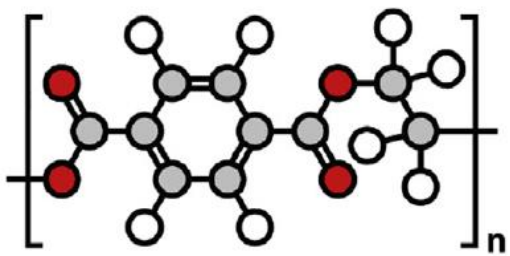


PET

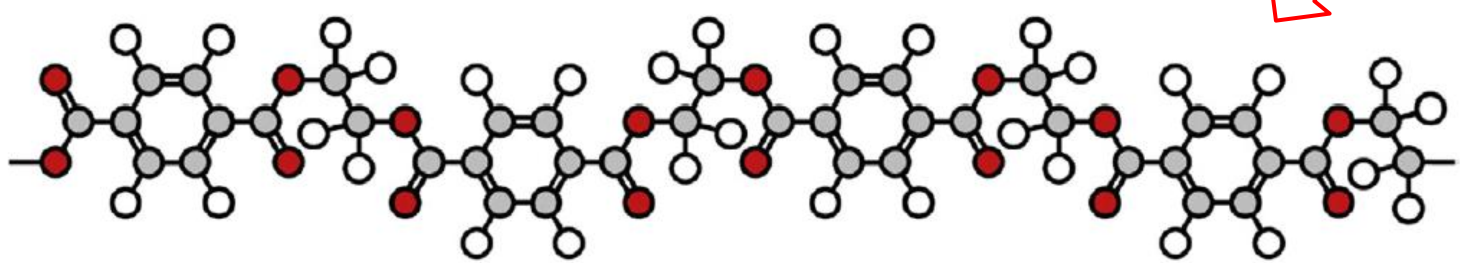


Ácido tereftálico

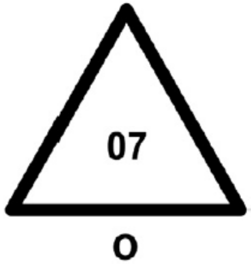




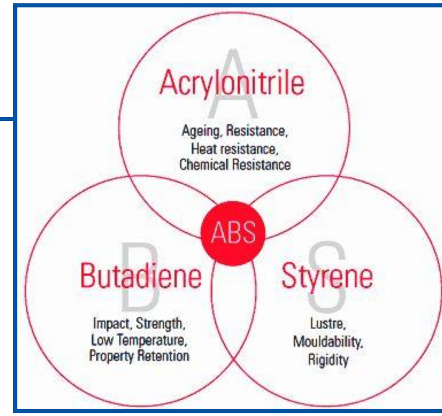
Etilentereftalato

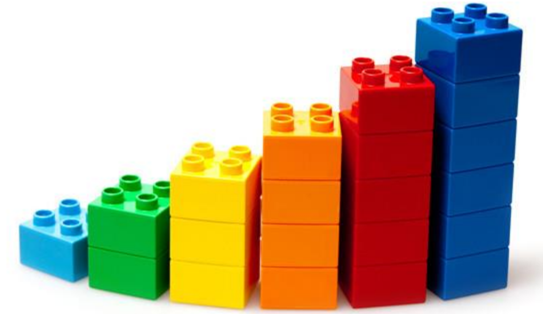


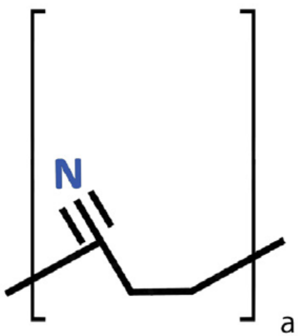
Polietilentereftalato



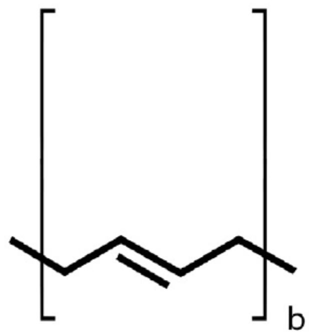
ABS



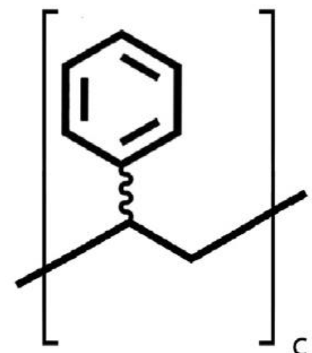




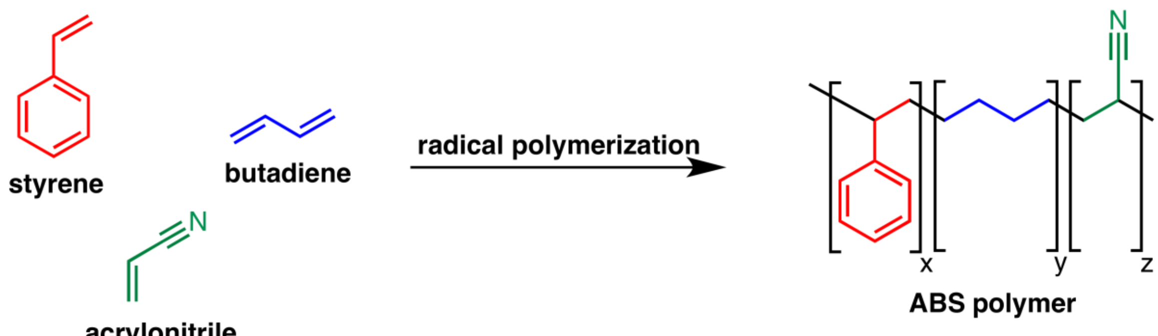
Acrilonitrilo



Butadieno



Estireno



Utilizados en una amplia gama de aplicaciones

empaquetado, construcción, automóvil, aeronáutica, equipos eléctricos y electrónicos, agricultura, ocio, equipamiento deportivo, dispositivos médicos, …

PETRÓLEO

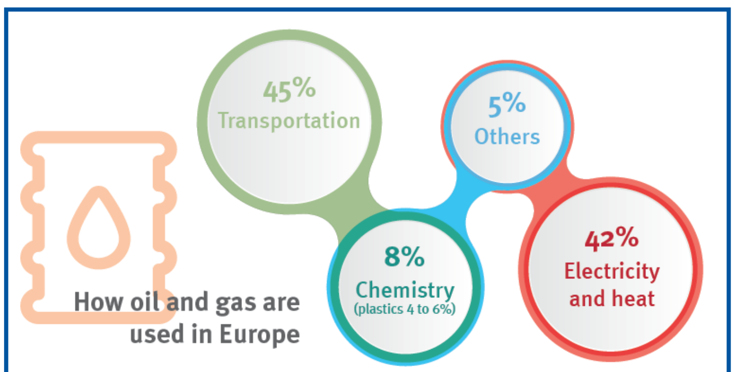
CELULOSA

CARBÓN

¿DE DÓNDE DERIVAN?

BIOPLÁSTICOS

GAS NATURAL



(PlasticsEurope, 2016)

(http://lavidavamagazine.com)

Cifras de Plásticos en el Mundo

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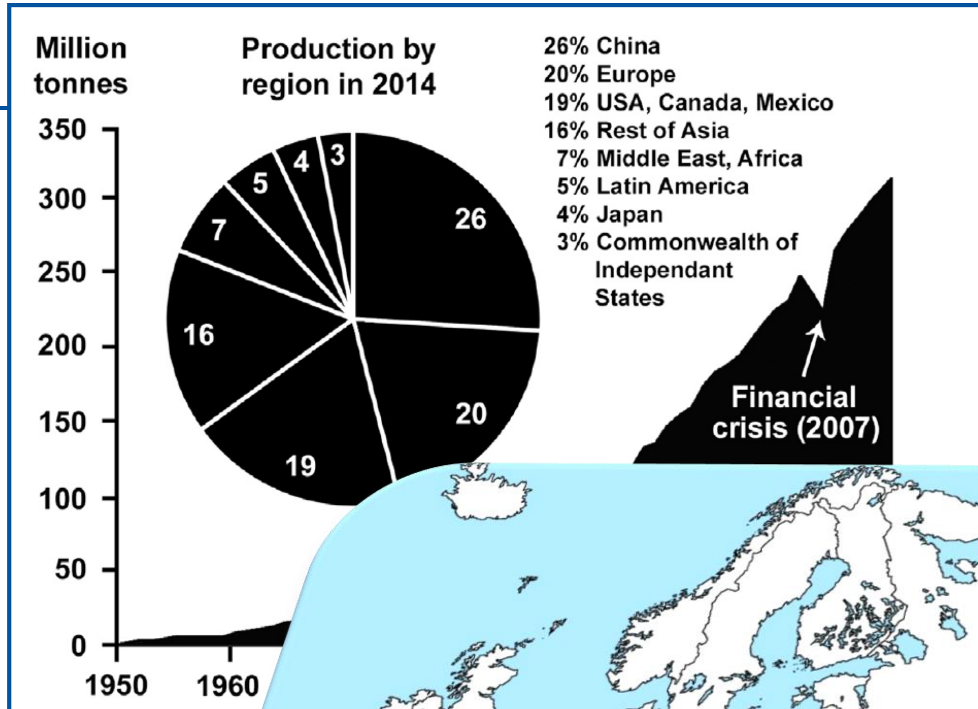
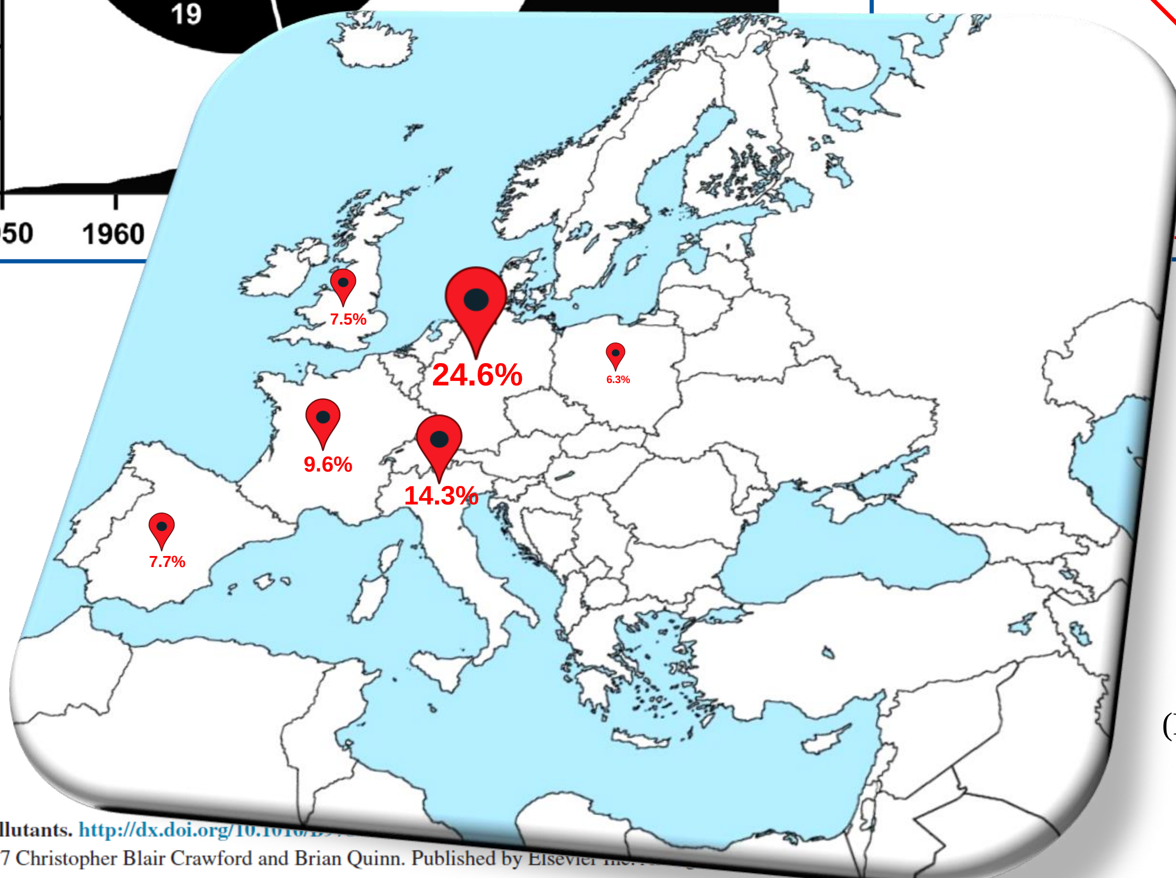


1,7·10^6 ton (1959)

ton (2014)

tico/hab ·año



(PlasticsEurope, 2016)

Microplastic Pollutants. http://dx.doi.org/10.1016/B9...

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Cifras de Plásticos en Europa

Empleos

La industria del plástico da empleo directo a más de 1,5 millones de personas en Europa

Empresas

Cerca de 60.000 empresas, la mayoría PYMES

Volumen de Negocios

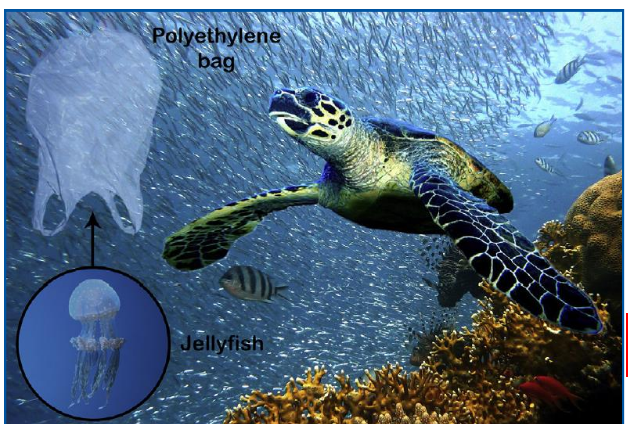
La industria del plástico en Europa tuvo un volumen de negocio de más de 340 billones de € en 2015

Reciclado

En 2014, se recogieron más de 7,5 toneladas de residuos plásticos para su reciclado

(PlasticsEurope, 2016)

15-40% (land-based)



33% NO REUTILIZABLE

Microplastic Pollutants. http://dx.doi.org/10.1016/B978-0-12-809406-8.00003-7

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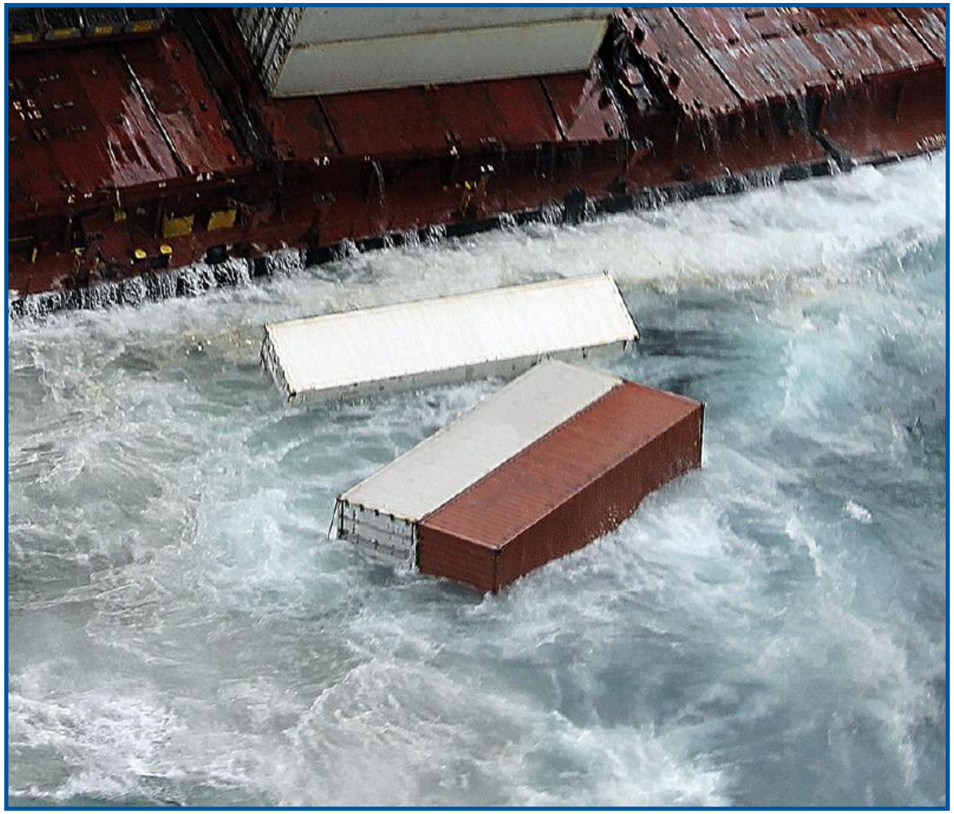
Generación de Residuos Plásticos



CONTENEDORES PERDIDOS EN EL MAR

Microplastic Pollutants. http://dx.doi.org/10.1016/B978-0-12-809406-8.00003-7

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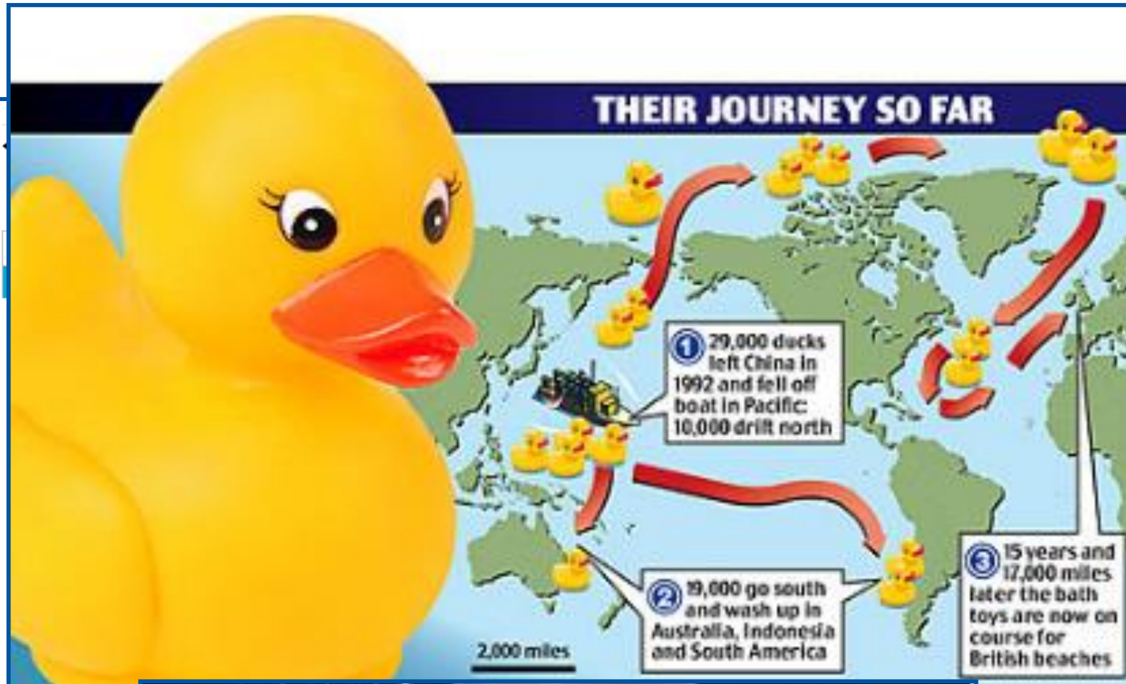
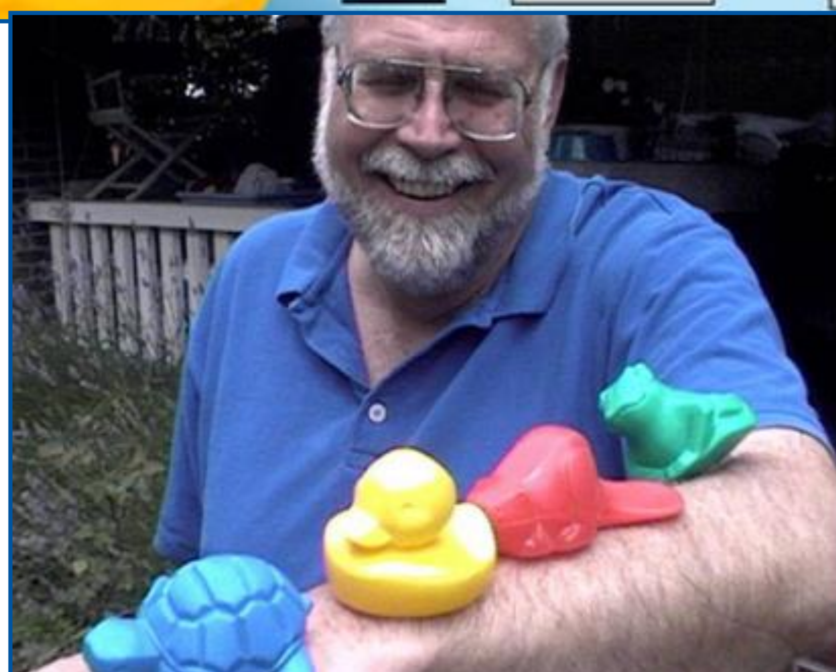
Generación de Residuos Plásticos





1 HISTORIA DE LOS MICROPLÁSTICOS

PLASTIC PARTICLES

REPORTS

Plastics on the Sargasso Sea Surface

Edward J. Carpenter[1], K. L. Smith Jr.[1]
+ See all authors and affiliations

Science 17 Mar 1972:
Vol. 175, Issue 4027, pp. 1240-1241
DOI: 10.1126/science.175.4027.1240

∅ ≥ 25 mm → MACROPLÁSTICOS

5 mm ≤ ∅ < 25 mm → MESOPLÁSTICOS

∅ < 5 mm → MICROPLÁSTICOS

- 1 mm ≤ ∅ < 5 mm → GRANDES MICROPLÁSTICOS (*“large”*)
- 1 µm ≤ ∅ < 1 mm → PEQUEÑOS MICROPLÁSTICOS Ó MINI-MICROPLÁSTICOS (*“small”*)
- ∅ < 1 µm → NANOPLÁSTICOS (*“nano”*)

NANOPLÁSTICOS

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NANOPLÁSTICOS

NANOPLÁSTICOS

FUENTES

DESTINO

EFECTOS

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NANOPLÁSTICOS

1 FUENTES DE LOS NANOPLÁSTICOS

DEFINICIÓN DE NP

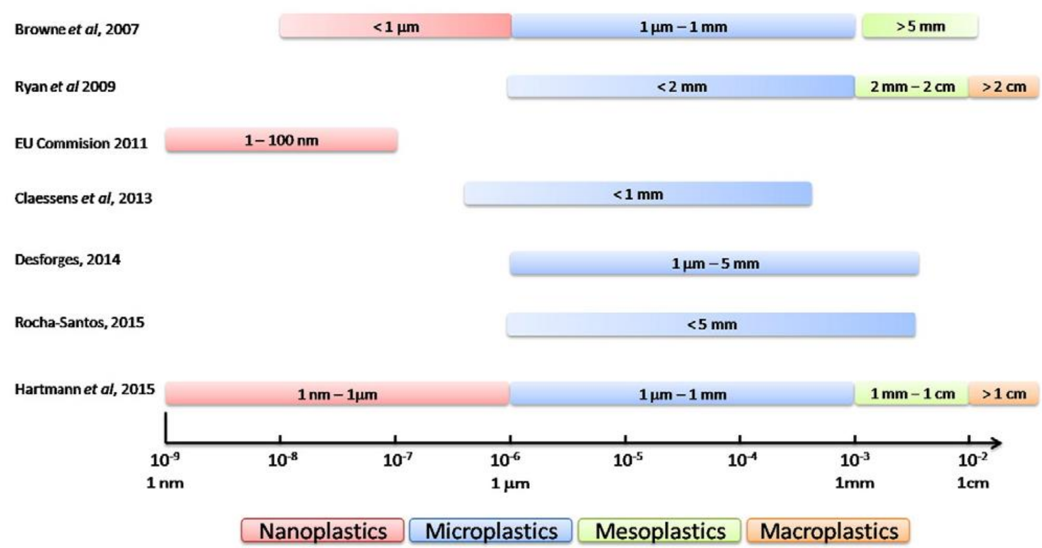

Fig. 1. A size-based definition of plastics as proposed by different authors (Rocha-Santos and Duarte 2015, Hartmann et al. 2015, Browne et al. 2007, Ryan et al. 2009, EUCommision 2011, Claessens et al. 2013, Desforges et al. 2014).

(Fuente: da Costa *et al.*, 2016)

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NANOPLÁSTICOS

1 FUENTES DE NANOPLÁSTICOS

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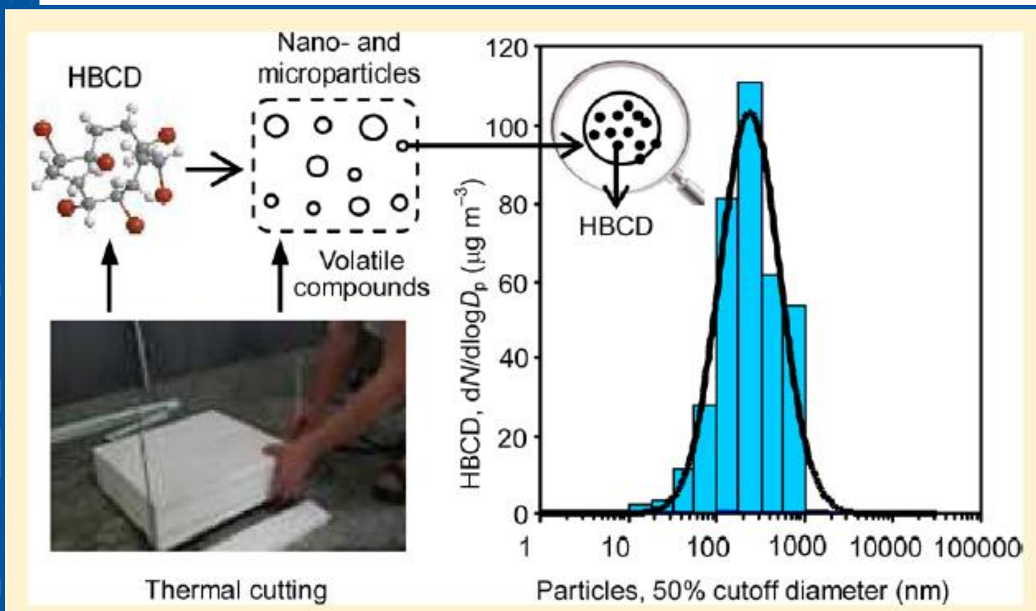
1 FUENTES DE NANOPLÁSTICOS

ESTUDIOS RECIENTES DE NP

Corte térmico de espuma de poliestireno (Zhang *et al.*, 2012)



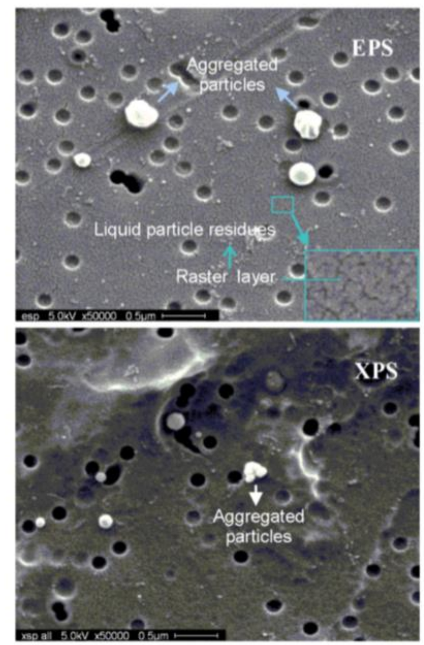


Figure 5. SEM images (×50 000) of particles generated from the thermal cutting of expanded polystyrene foam (EPS) and extruded polystyrene foam (XPS).

Environmental Science & Technology
Article
pubs.acs.org/est

Co-Release of Hexabromocyclododecane (HBCD) and Nano- and Microparticles from Thermal Cutting of Polystyrene Foams

Haijun Zhang,[§] Yu-Ying Kuo,[†,‡] Andreas C. Gerecke,[*,†] and Jing Wang[*,†,‡]

[†]Empa, Swiss Federal Laboratories for Materials Science and Technology, Dübendorf CH-8600, Switzerland
[‡]Institute of Environmental Engineering, ETH Zurich, Zurich CH-8093, Switzerland
[§]Dalian Institute of Chemical Physics, Chinese Academy of Sciences, Dalian 116023, China

1 FUENTES DE NANOPLÁSTICOS

ESTUDIOS RECIENTES DE NP

Impresoras 3D (Stephens *et al.*, 2013)

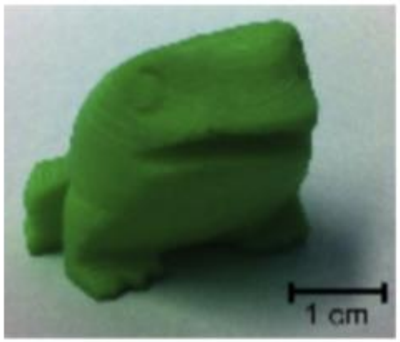


Fig. 1. Example of a three-dimensionally printed frog in this study.

11,5 – 116 nm

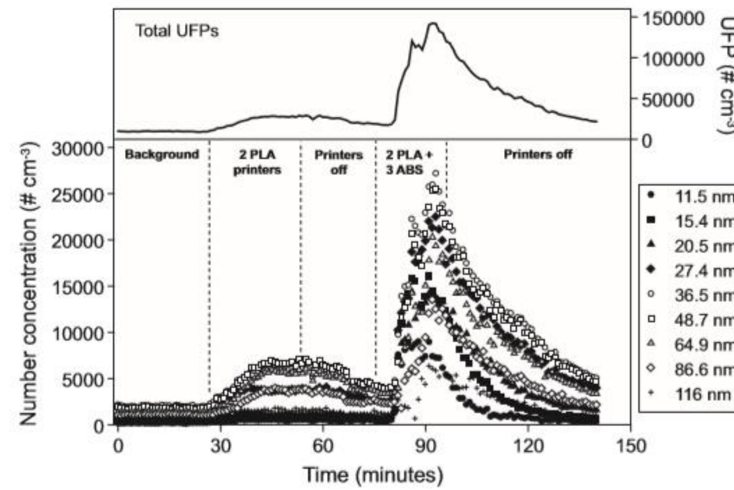


Fig. 2. Size-resolved and total (<100 nm) ultrafine particle (UFP) concentrations measured in the office space during the sampling campaign.

Atmospheric Environment 79 (2013) 334–339

Contents lists available at SciVerse ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

ELSEVIER

ATMOSPHERIC ENVIRONMENT

Technical note

Ultrafine particle emissions from desktop 3D printers

CrossMark

Brent Stephens [a,*], Parham Azimi [a], Zeineb El Orch [a,b], Tiffanie Ramos [a]

[a] Department of Civil, Architectural and Environmental Engineering, Illinois Institute of Technology, Chicago, IL, USA
[b] National Institute of Applied Sciences (INSA de Lyon), Lyon, France

2 DESTINO DE NANOPLÁSTICOS

BASURA PLÁSTICA EN LOS OCÉANOS

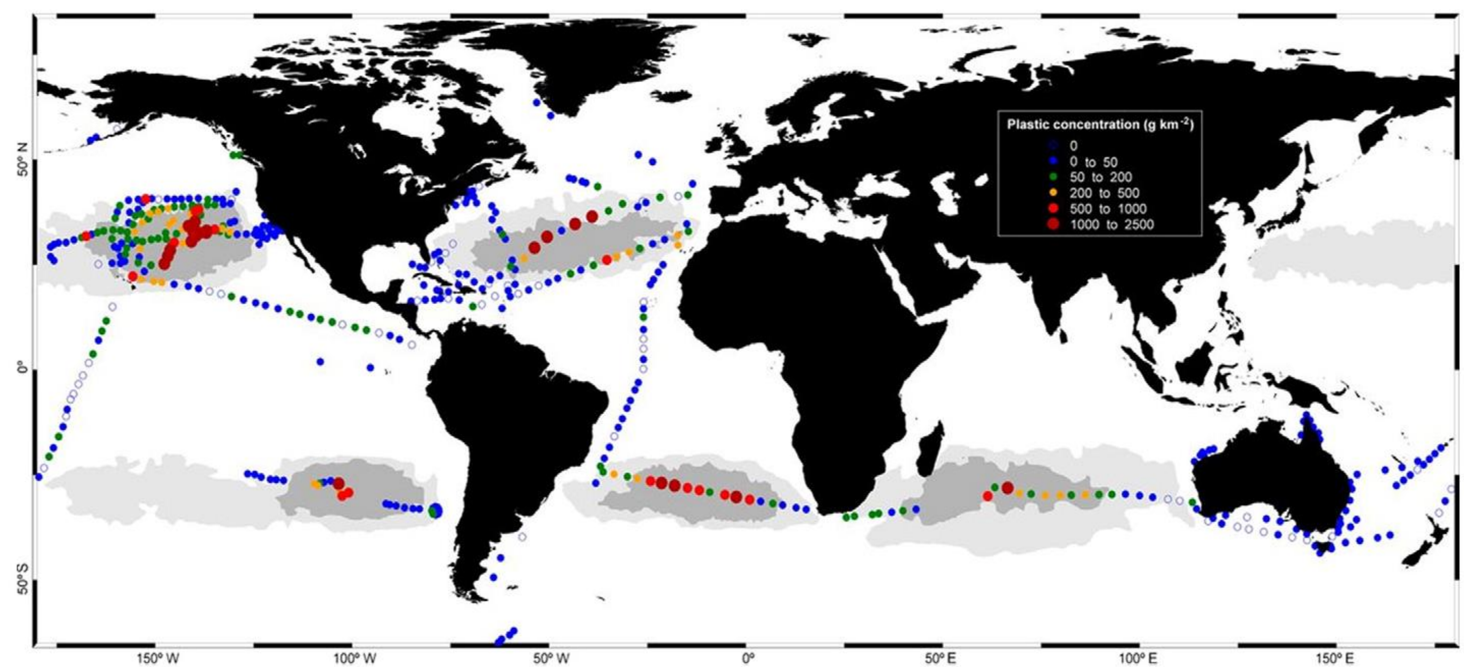


Fig. 2. Concentrations of plastic debris in oceans' surface waters. Colored circles indicate mass concentrations. The average concentrations in 442 sites (corresponding to 1127 surface net tows) are shown. Gray areas indicate the accumulation zones (gyres) predicted by the global surface circulation model developed by Maximenko et al. (Maximenko et al. 2012). Dark and light gray represent inner and outer accumulation zones, respectively. Though mostly referring to microplastics, and considering the inherent difficulty in the sampling of nano-sized polymers, these data may hint at the possible fate of nanoplastics in the oceans Fig. by (Cózar et al. 2014), copyright © by the National Academy of Sciences.

da Costa *et al.* (2016)

2 DESTINO DE NANOPLÁSTICOS

HETEROAGREGACIÓN (Wang *et* al., 2015)

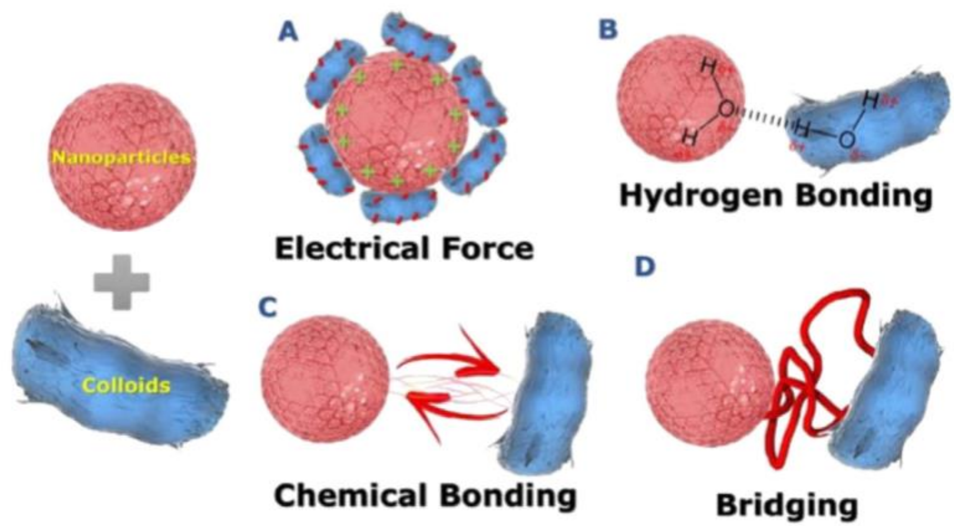


Fig. 2. Mechanisms of heteroaggregation between NPs and colloids (A – electrical forces; B – hydrogen bonding; C – chemical bonding; and D – bridging).

Advances in Colloid and Interface Science 226 (2015) 24–36
Contents lists available at ScienceDirect
Advances in Colloid and Interface Science
journal homepage: www.elsevier.com/locate/cis
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Historical perspective

Heteroaggregation of nanoparticles with biocolloids and geocolloids

Hongtao Wang [a,*], Adeyemi S. Adeleye [b], Yuxiong Huang [b], Fengting Li [a], Arturo A. Keller [b,**]

[a] State Key Laboratory of Pollution Control and Resource Reuse, Key Laboratory of Yangtze River Water Environment, Ministry of Education, College of Environmental Science and Engineering, Tongji University, Shanghai, 200092, China
[b] Bren School of Environmental Science and Management, University of California, Santa Barbara, CA, 93106, USA

2 DESTINO DE NANOPLÁSTICOS

HETEROAGREGACIÓN CON FULERENO C60 (Dong *et* al., 2019)

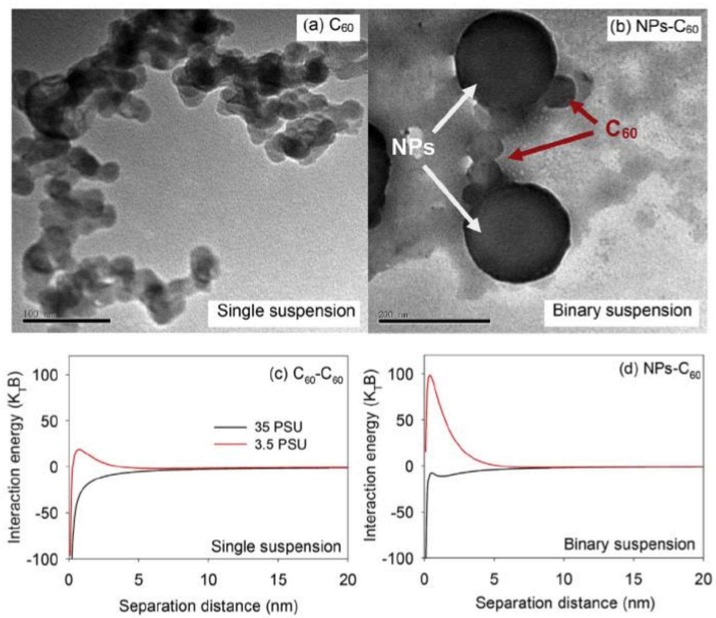
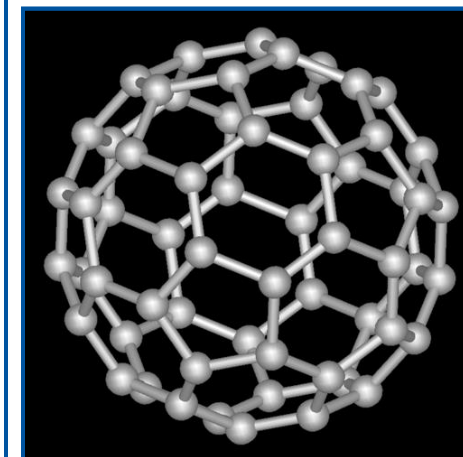


Fig. 1. TEM images of C_{60} in single suspension (a) and NPs/C_{60} (1:1) in binary suspension (b) at 35 PSU. Total interaction energy (KBT) as a function of separation distance (nm) in accordance with DLVO theory for C_{60}–C_{60} in single suspension (c) and NPs-C_{60} (1:1) in binary suspension (d) indifferent solution systems.



Water Research 148 (2019) 469–478

Contents lists available at ScienceDirect

Water Research

journal homepage: www.elsevier.com/locate/watres

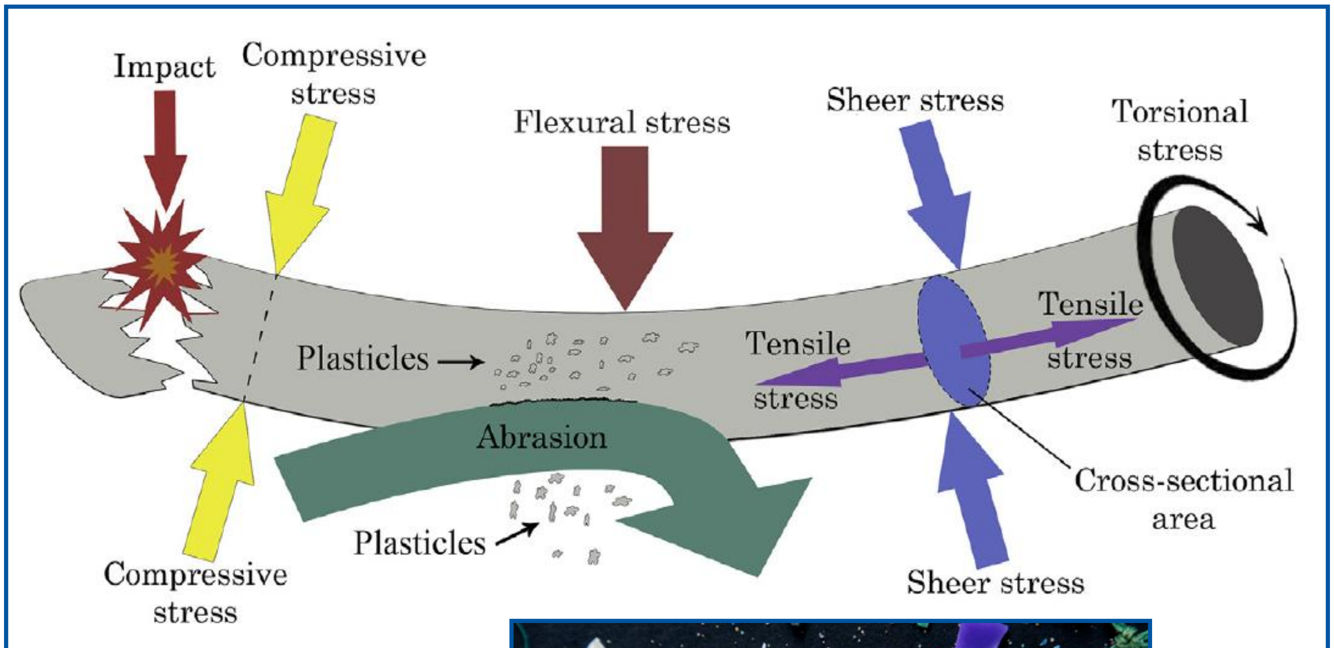
Cotransport of nanoplastics (NPs) with fullerene (C_{60}) in saturated sand: Effect of NPs/C_{60} ratio and seawater salinity

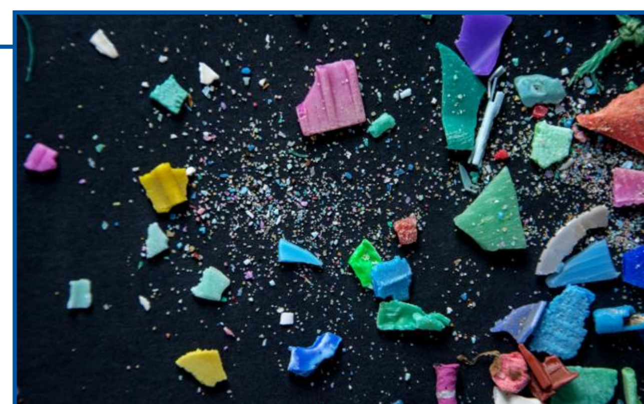
Zhiqiang Dong [a, b], Wen Zhang [a, b], Yuping Qiu [a, b, *], Zhenglong Yang [c], Junliang Wang [d], Yidi Zhang [a]

[a] State Key Laboratory of Pollution Control and Resource Reuse, Ministry of Education Key Laboratory of Yangtze River Water Environment, College of Environmental Science and Engineering, Tongji University, Shanghai, 200092, China
[b] Shanghai Institute of Pollution Control and Ecological Security, International Joint Research Center for Sustainable Urban Water System, Shanghai, 200092, PR China
[c] School of Materials Science and Engineering, Jiading Campus, Tongji University, Shanghai, 201804, China
[d] School of the Environment, Zhejiang University of Technology, Hangzhou, 310014, China

2 DESTINO DE NANOPLÁSTICOS

OTROS PROCESOS





2 DESTINO DE NANOPLÁSTICOS

OTROS PROCESOS

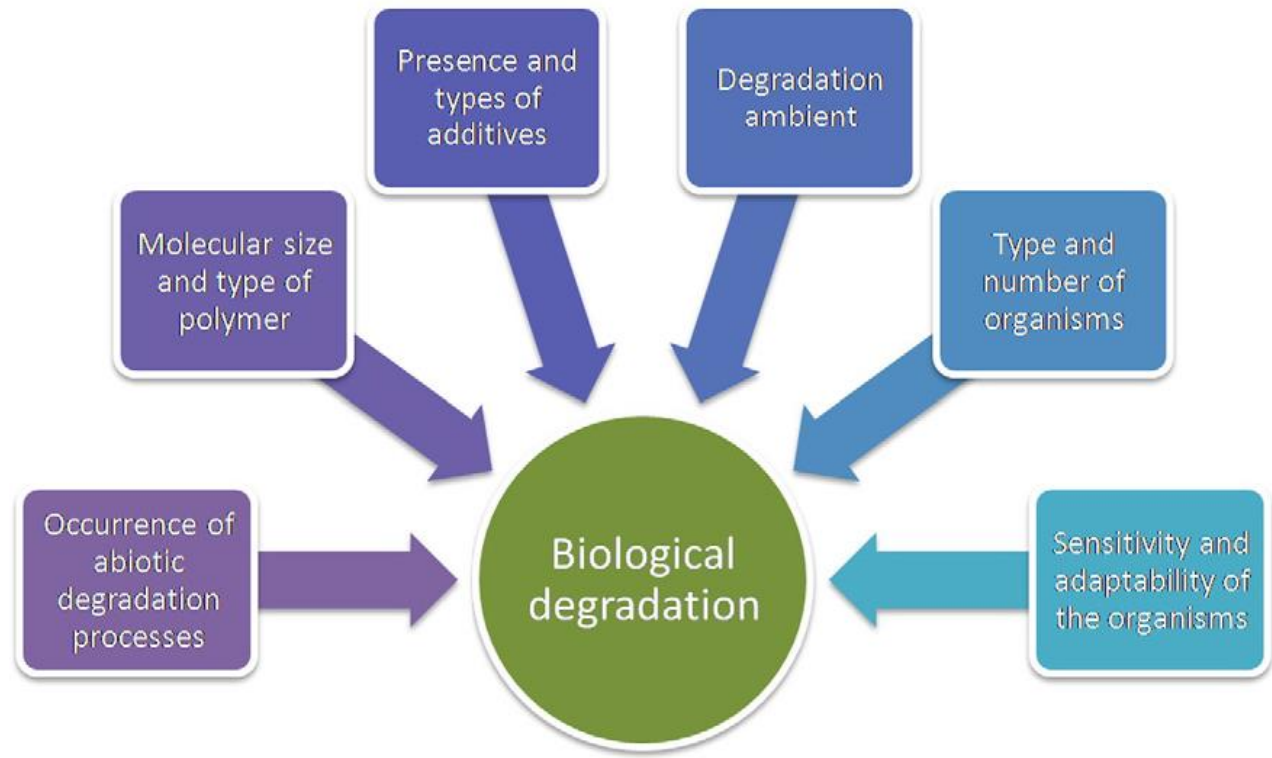


Fig. 3. Main factors responsible for the biodegradation of polymers. Color was used for aesthetic purposes.

da Costa *et al.* (2016)

2 DESTINO DE NANOPLÁSTICOS

OTROS PROCESOS

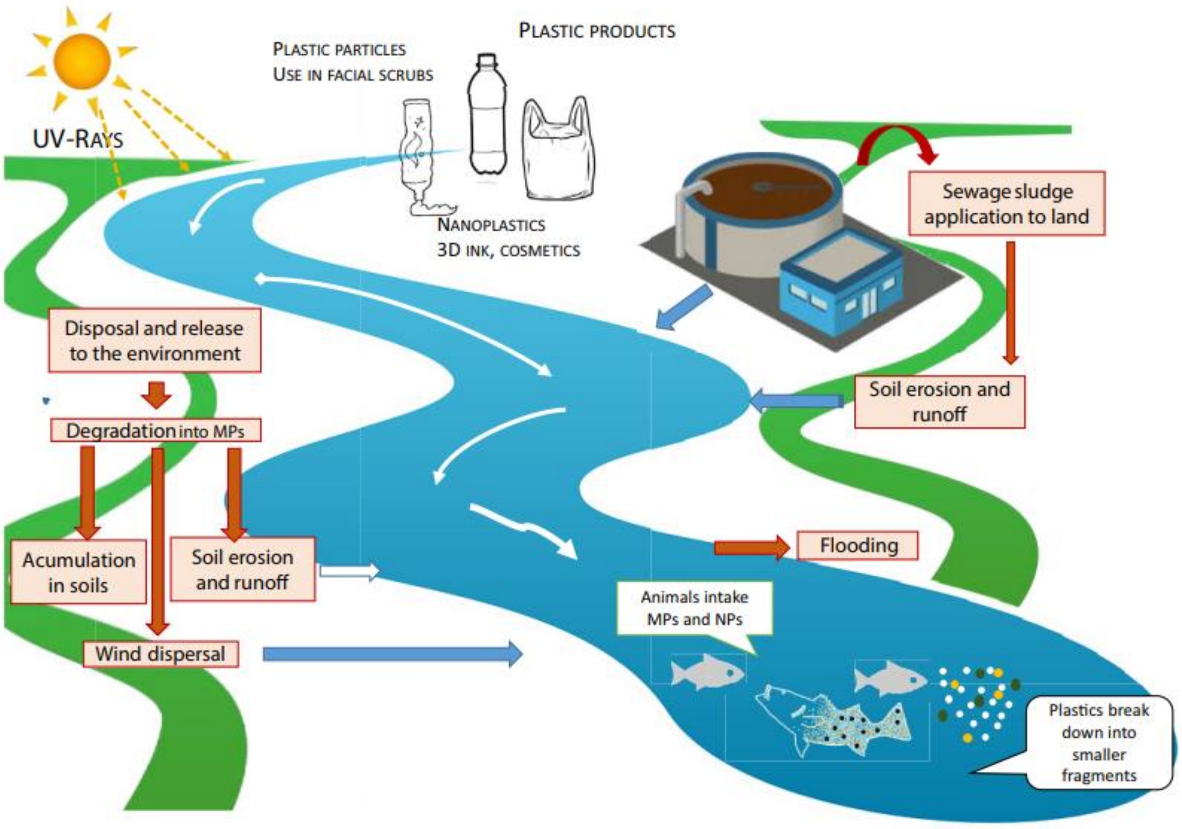


Fig. 2. Conceptual map of the source, transport, and fate of MPs and NPs.

Pico *et al.* (2018)

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NANOPLÁSTICOS

3 EFECTOS DE NANOPLÁSTICOS

NANOPOLIESTIRENO (Cedervall *et* al., 2012)

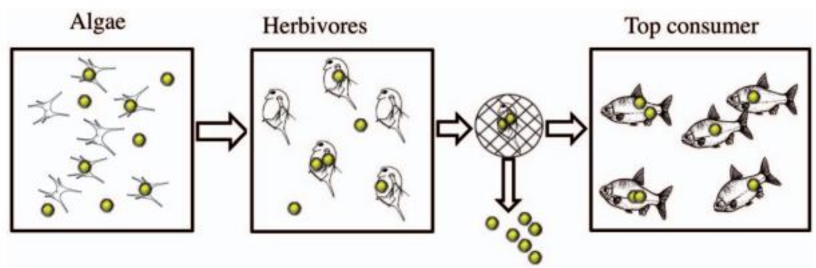

Figure 1. Cartoon illustrating the test food chain with 24 nm polystyrene nanoparticles added at a concentration of 0.01% (w/v) to an algal culture, which after 24 h was filtered and fed to herbivorous zooplankton (algae from 250 ml culture given to 30 adult *Daphnia*). After another 24 h, the zooplankton were gently washed on a net in order to remove remaining or released free nanoparticles before zooplankton were presented to the top consumers of the food chain (fish; 4 individuals per replicate tank). The food chain was restarted every third day and the fish remained the same throughout the study. The control food chain was operated in the same way except that no nanoparticles were added. Each food chain started with 16 fish divided into four tanks. The number of fish in each tank decreased over time due to sacrifice of fish for sampling.
doi:10.1371/journal.pone.0032254.g001

OPEN ACCESS Freely available online PLoS one

Food Chain Transport of Nanoparticles Affects Behaviour and Fat Metabolism in Fish

Tommy Cedervall[1], Lars-Anders Hansson[2], Mercy Lard[2¤], Birgitta Frohm[1], Sara Linse[1*]

1 Chemical Centre, Department of Biochemistry and Structural Biology, Lund University, Lund, Sweden, 2 Department of Biology/Aquatic Ecology, Lund University, Lund, Sweden

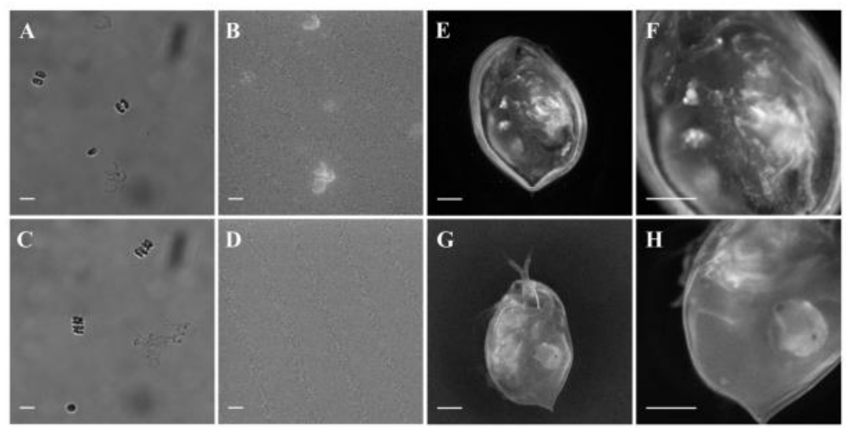

Figure 5. Fluorescence and bright field images of test and control algae and *Daphnia*. A. Bright field images of algae taken from test sample, After 24 h incubation with 28 nm fluorescently labeled nanoparticles. **B.** Fluorescence micrograph of algae from A, imaged with Deep Blue filter cube (see Methods), here algal cells are fluorescent due to adsorption of fluorescently labeled nanoparticles. **C.** Bright field images of algae taken from control sample. **D.** Fluorescence micrograph of algae from C, imaged with Deep Blue filter cube, here algal cells are clearly non-fluorescent. Scale bars, A–D: 10 µm. **E.** Fluorescence micrograph of *Daphnia*, taken after 24 hrs incubation with test algae and a light wash through filter. **F.** Close up of E, nanoparticles can be seen in and on the *Daphnia*. **G.** Fluorescence micrograph of control *Daphnia*, taken after 24 hrs incubation with control algae and a light wash through filter. **H.** Close up of G, note some auto-fluorescence in the gut and heart and developing offspring, much of which is distributed evenly. Scale bars, E–H: 500 µm.
doi:10.1371/journal.pone.0032254.g005

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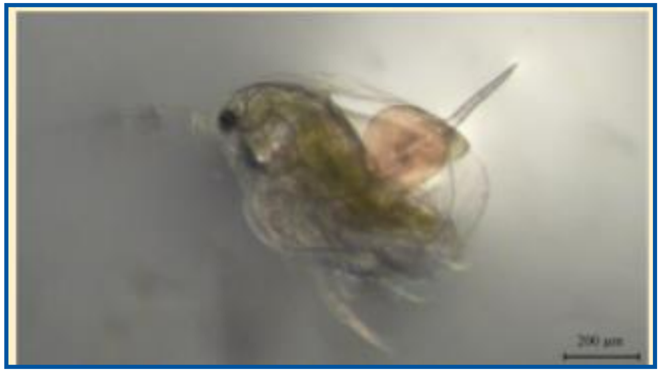
NANOPLÁSTICOS

3 EFECTOS DE NANOPLÁSTICOS

CRECIMIENTO (Besseling *et* al., 2014)



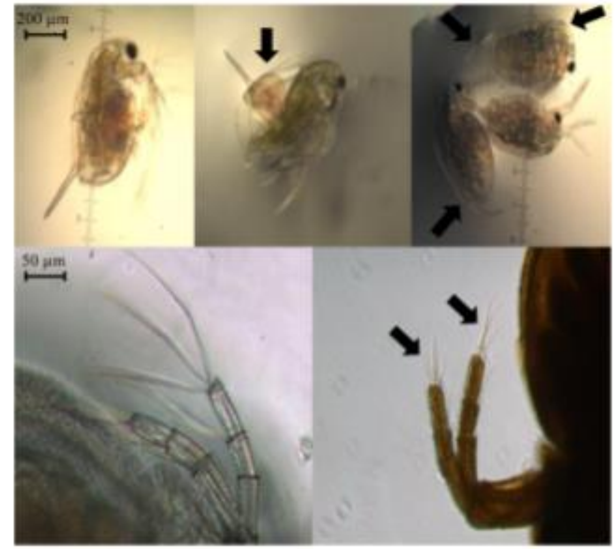


Figure 5. Malformations in different developmental stages of *Daphnia* neonates. Top-right: incomplete developed antenna setae, curved shell spine and vacuoles around ovary. Top-middle: lump in the carapace. Top-left: normal developed neonate. Bottom-right: short antenna setae. Bottom-left: normal developed antenna setae. The arrows depict malformed body parts.

Environmental Science & Technology

Article

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Nanoplastic Affects Growth of *S. obliquus* and Reproduction of *D. magna*

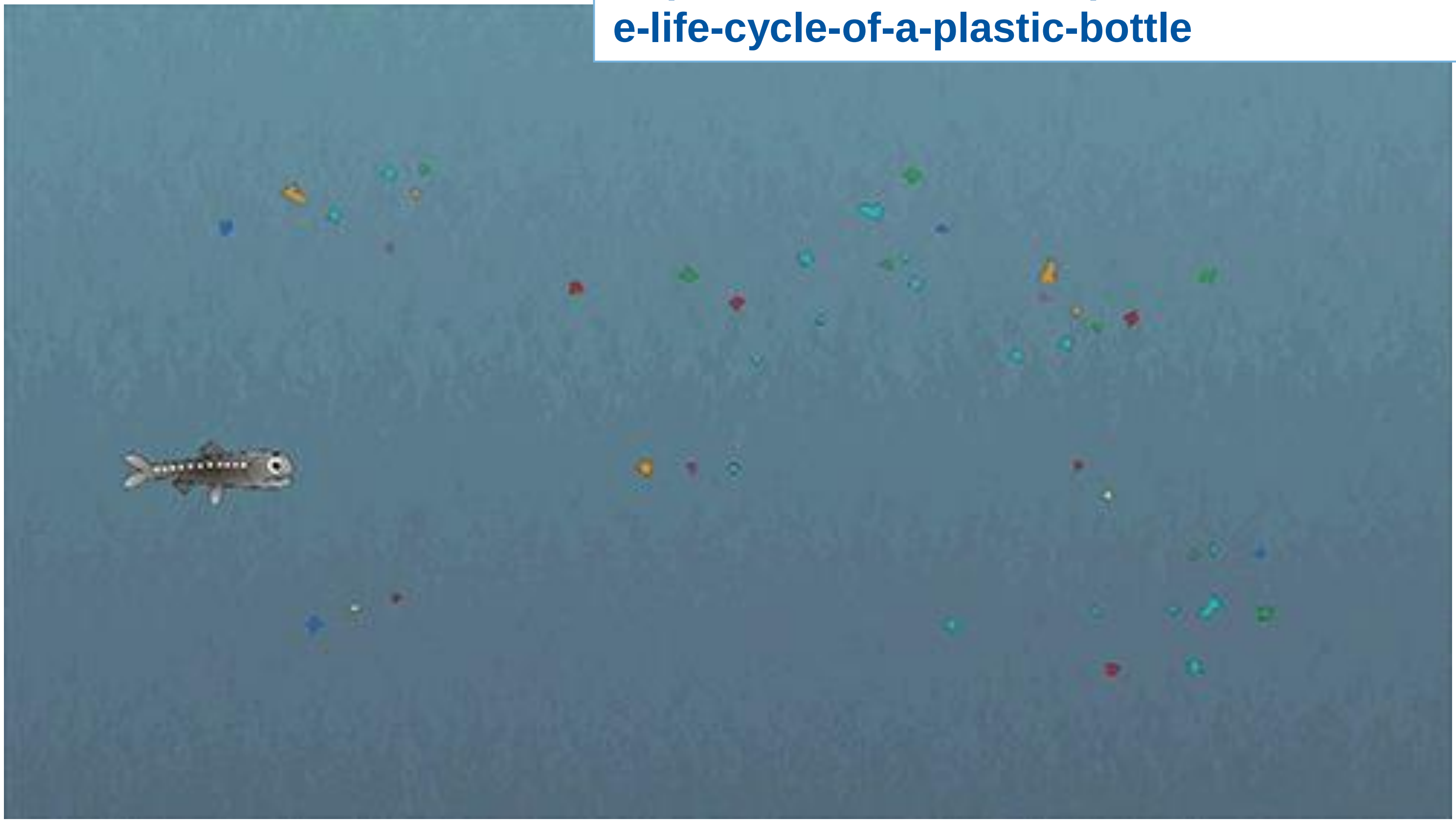
Ellen Besseling,*[†,‡] Bo Wang,[†] Miquel Lürling,[†] and Albert A. Koelmans[†,‡]

[†]Aquatic Ecology and Water Quality Management Group, Wageningen University, P.O. Box 47, 6700 AA Wageningen, The Netherlands

[‡]IMARES – Institute for Marine Resources & Ecosystem Studies, Wageningen UR, P.O. Box 68, 1970 AB IJmuiden, The Netherlands

4 CONCLUSIONES Y DESAFÍOS FUTUROS

http://teded.tumblr.com/post/117084115048/the-life-cycle-of-a-plastic-bottle



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NANOPLÁSTICOS

4 CONCLUSIONES Y DESAFÍOS FUTUROS

⇒ **No suficientes NPs aislados en el medio ambiente como para estudios reales de toxidad.**

⇒ **Concentraciones en el medio ambiente *vs.* concentraciones probadas en laboratorio.**

⇒ **No actúan aislados en el medio ambiente: sinergias – estresante ecológico.**

⇒ **¿Cuál es la contribución de los NPs a los nanomateriales ya existentes en el medio ambiente?**

⇒ **Investigaciones futuras: fuentes – velocidad de formación – niveles reales de exposición – métodos de detección.**

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