Imperial College London

EVALUATING THE SUITABILITY OF BALL-MILLING FOR SIMULATING ENVIRONMENTAL DEGRADATION OF PLASTICS

Chun Ki Kitty Chau Department of Civil and Environmental Engineering
Supervisors: Professor Christopher Cheeseman, Dr Thomas Bond, Dr Veronica Ferrandiz

E4

DEGRADATION OF PLASTICS IN THE OCEAN

Plastics undergo a combination of mechanical, chemical and biological degradation processes in the ocean. Mechanical degradation of plastics is induced by various environmental forces such as waves at the surface and in the littoral zone, turbulent motion, stokes drifts, abrasion by sand shearing with marine debris and beaching.

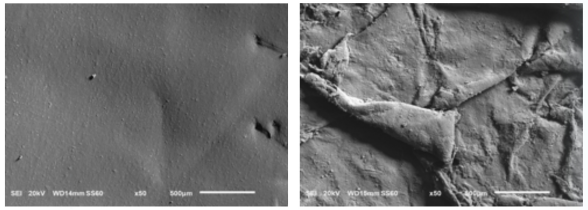
FORMATION OF MICRO AND NANO-PLASTICS

Mechanical stress causes formation and growth of cracks, plastic deformation and creep in plastics. The degraded surface is susceptible to mechanical stress leading to fragmentation. Larger plastics particles will be broken down to smaller fragments forming micro and nano-plastics.

INTRODUCTION

Many environmental problems are associated with the presence of micro-plastics in the ocean. There have been limited efforts to study the degradation of plastics under controlled laboratory conditions which simulate those found in the environment. The aim of this research was to evaluate the suitability of using a laboratory ball-mill to simulate the mechanical degradation process of plastics in the ocean and characterise the fine plastic particles generated. Five representative types of waste plastic were milled in deionised water to mimic the various physical forces found in the marine environment.

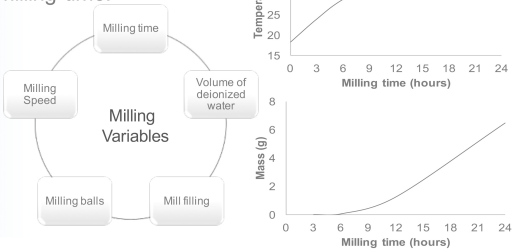
ANALYSE DEGRADED PLASTICS

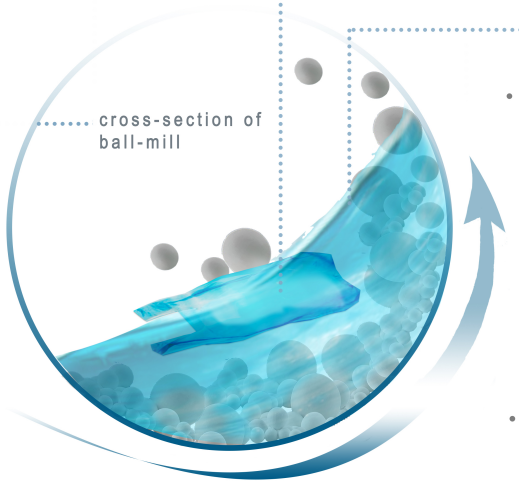


Scanning electron microscopy images (magnified x50) of **original** Waitrose plastic bag and after **24 hours of milling**

OPTIMISE CONDITIONS OF BALL-MILLING

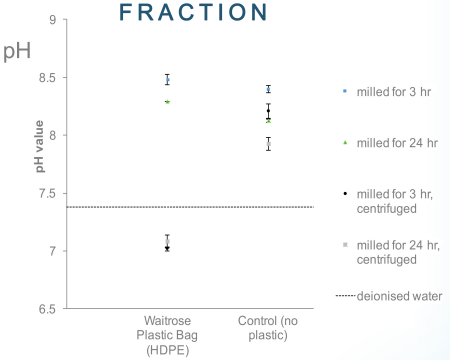
Ball milling conditions were optimised to accelerate the physical degradation processes. Control experiments were undertaken in the absence of plastic to study the temperature effects and formation of ceramic particles from the inner-wall of the milling pot with different milling time.





ANALYSE LIQUID FRACTION

- pH



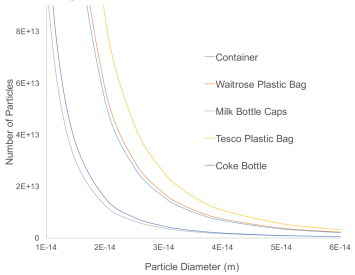
- Total organic carbon

	3 hours milling	24 hours milling
TOC (mg/l)	4.2	8.5

MASS BALANCE OF PLASTICS

Mass balance measurement shows that 0.3-3.3% of the starting material was accounted for in either the solid or liquid fractions of milled samples after wet-milling. The number of micro-plastics released from the original plastics were estimated.

Plastic material	Polymer	Density of polymer g/cm³	% Mass loss after 24 hours milling
Container	Polypropylene (PP)	0.90	1.7%
Waitrose Plastic Bag	High-density polyethylene (HDPE)	0.95	3.3%
Milk Bottle Caps	High-density polyethylene (HDPE)	0.95	0.3%
Tesco Plastic Bag	Low-density polyethylene (LDPE)	0.92	2.8%
Coke Bottle	Polyethylene terephthalate (PET)	1.385	0.4%
Foamed Cup	Expanded Polystyrene (PS)	0.01	N/A



CONCLUSIONS

Given that there is currently no laboratory experiment being undertaken to simulate the marine mechanical degradation process, the ball-mill experiment provides insight on environmental degradation simulation under controlled laboratory conditions, even though the experiment suffered from contamination from the milling pot. Further research is required to assess if ball milling is a viable method of producing micro and nano-particles from plastics and how this relates to plastic degradation in the oceans.

ACKNOWLEDGEMENTS

I would like to thank Professor Christopher Cheeseman, Dr Thomas Bond and Dr Veronica Ferrandiz for their support during the length of this project and Dr Jonathan Ritson for the help with the TOC analysis.

REFERENCES

Roncaglia and Wijkander (2010) Marevivo Anti-Pollution-*"Don't compromise the sea and the beach"* . Available from: http://joelapompe.net/2015/06/10/food-chain-pollution-plastic-bag [Accessed: 6th June 2016].