New Application of Emulsification Technology for the SDGs Era

~Reducing waste through control of emulsification and separation~

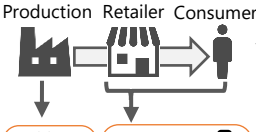
POLA R&M
POLA CHEMICAL INDUSTRIES,INC.

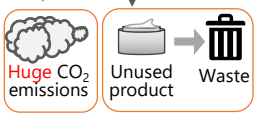
Yuki Kimura; Keiichiro Seta; Megumi Kaji
POLA Chemical Industries, Inc., Yokohama, Kanagawa, Japan,

Poster ID 382

Introduction

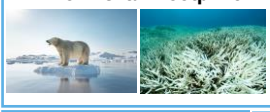
Production Retailer Consumer





- Conventional emulsifiers need a heating process to make stable emulsions
- Due to the heating process, emulsions emit a huge amout of CO_2 during production
- Due to high stability, emulsions are very difficult to separate and recycle

Environmental footprint



Purpose

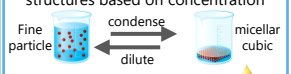
Reduction of CO_2 emissions and enabling recycling of emulsions

Hypothesis

Emulsification/separation can be controled by heteroaggregation

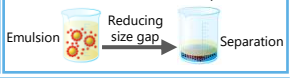
To realize our purpose, we used M-polymer, an amphiphilic polymer.

- M-polymer forms different structures based on concentration

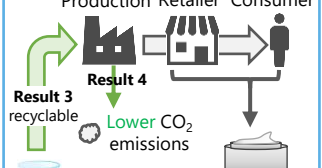


- These fine particles emulsify oil by heteroaggregation

By reducing the size gap between oil droplets and M-polymer, heteroaggregation can be inhibited and an emulsion can be separated.



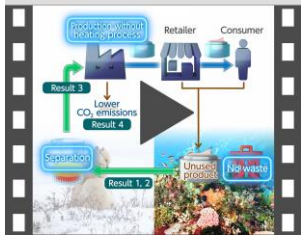
Conclusion



Use of M-polymer reduced production related CO_2 emissions

M-polymer containing emulsions are recyclable

This findings ~summary movie~



Study flow

Observe Emulsion

Observed by FT-SEM (A)

Evaporate water (35°C 2 hours)

Observed by Raman microscope(B)

Recovering M-polymer

Prepare the emulsion with a volatile oil

Evaporate water and oil by evaporater

Quantitative analysis by NMR

Recyclability of M-polymer

Recovered materials

Re-prepare emulsion with no heating

Emulsion particle evaluation(A) and sensory test(B)

Calculation of CO_2 reduction

Made with conventional emulsifier

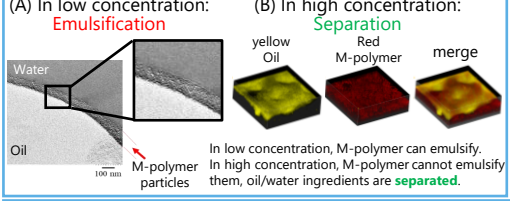
Replace the emulsifier

Made with M-polymer

Result 1: Emulsification/separation are controlled concentration-dependently

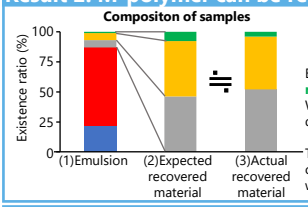
(A) In low concentration: Emulsification

(B) In high concentration: Separation



In low concentration, M-polymer can emulsify. In high concentration, M-polymer cannot emulsify them, oil/water ingredients are **separated**.

Result 2: M-polymer can be recovered from emulsions without oil contamination



By condensing the emulsion, we could **recover ingredients** from the emulsion (3). We also found that the recovered material didn't contain oil.

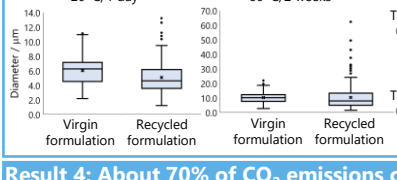
The composition of recovered material was close to the composition of the emulsion without water/oil ingredients (2).

Numerical values in graph

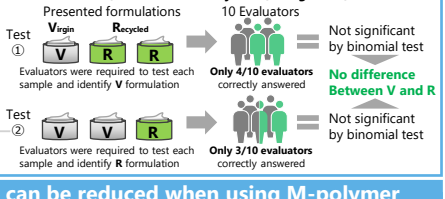
	(1) Emulsion (blending ratio)	(2) Expected recovered material (existence ratio)	(3) Actual recovered material (existence ratio)
Water	22 wt%	0 wt%	0 wt%
Isododecane	65 wt%	0 wt%	0 wt%
M-polymer	1 wt%	7.7 wt%	4.1 wt%
Glycerin	6 wt%	46.15 wt%	52.1 wt%
1,3-BG	6 wt%	46.15 wt%	43.8 wt%
total	100	100	100

Result 3: Ability of M-polymer as an emulsifier is unchanged after recovery

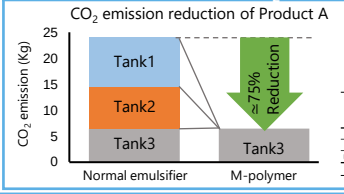
A) Emulsion particle size



B) Result of sensory test (triangle test)



Result 4: About 70% of CO_2 emissions can be reduced when using M-polymer



Heating/steam/used gas volume are used to calculate CO_2 emission. Tank 1 is the main tank. After preheating, Tank 2 is added to Tank 1. After the emulsification is formed, Tank 3 is added to Tank 1 to form the final product.

Numerical values used for CO_2 calculation

Product A **normal emulsifier**	Tank1 emulsify	Tank2 Pre-heating	Tank3 dissolve	Sum
Heating vol. (MJ)	151	126	100	377
Steam vol. (kg)	69	58	46	173
Used gas vol. (Nm^3)	4.3	3.6	2.9	10.9
CO_2 emission (Kg)	**9.6**	**8.0**	**6.4**	**24.0**

Product A **M-polymer**	Tank1 emulsify	Tank2 pre-heating	Tank3 dissolve	Sum
Heating vol. (MJ)	0	0	100	100
Steam vol. (kg)	0	0	46	46
Used gas vol. (Nm^3)	0	0	2.9	2.9
CO_2 emission (Kg)	**0**	**0**	**6.4**	**6.4**

Discussion

We confirmed that M-polymer containing emulsion could be **separated and recycled**. In addition, we confirmed that the emulsion containing a volatile oil could be separated. Therefore, we thought that this recycling could be applied to all types of M-polymer containing emulsions. However, the recovery method used in this research used heating and the recovery rate of M-polymer was not high enough. To establish truly sustainable recycling, we must improve the recovery rate without using a heating process.

Methods in detail

Observation of emulsion (Result 1A)
1) An emulsion was prepared with M-polymer at 1 wt%, Dimethicone 30 wt%, water 69wt%
2) The emulsions were quickly frozen by liquid propane.
3) The frozen specimen was broken with a freeze replica fabricator
4) Platinum and carbon was deposited on the broken surface of the specimens.
5) The replica film was washed with acetone and water.
6) The specimen was observed using transmission electron microscope.

Observation of emulsion (Result 1B)
1) The emulsion was prepared with M-polymer 2 wt%, squalane 20 wt% glycerin 20 wt%, corboxyvinyl polymer 0.1 wt%, water 57.9 wt%
2) A few drops of the emulsion were dropped on a glass, applied evenly with a doctor blade
3) The emulsion was stored at 35°C for 2 hours to evaporate the water.
4) The dried film was measured using Taman microscope.

Recovering M-polymer(Result 2)
1) An emulsion was prepared with M-polymer 1 wt%, Isododecane 65 wt%, Glycerin 6 wt%, 1,3-BG 6 wt% and water 22 wt%
2) The emulsion was placed in a constant temperature box set at 60 °C for 2 weeks.
3) After aging, the emulsion was then concentrated by evaporator.
4) Qualitative and quantitative analysis using a nuclear magnetic resonance system was conducted to the concentrate.

Recyclability of M-polymer(Result 3A)
1) Recycle emulsion was prepared with concentrate from result 2 and Isododecane 65 wt%, water 22 wt%
2) At same time, virgin emulsion was prepared with M-polymer 1 wt%, Isododecane 65 wt%, Glycerin 6 wt%, 1,3-BG 6 wt% and water 22 wt% using new ingredients.
3) Each emulsion were placed at 20 °C for 1 day and at 60 °C for 2 weeks
4) After aging, three images were taken at 400x in different fields of view using an optical microscope
5) 100 emulsion particles were randomly selected per image, and the emulsion particle diameter was measured

Recyclability of M-polymer(Result 3B)
1) Recycled formulation(R) and virgin formulation (V) were placed for 2 weeks at 60 °C
2) After aging, Each formulation were sensory evaluated using the triangle test.
3) The evaluators were 10 in-house expert panelists, and the samples presented were (R, R, V) and (V, V, R).
4) This test was conducted with the approval of the ethical review board of POLA Chemical Industries, Inc. (approval number : 2022-F-039).

Recyclability of M-polymer(Result 4)
1) Based on the product manufacturing flow, the CO_2 emissions from manufacturing our Product A were calculated, and the CO_2 emissions were calculated if the heating process was no longer required.
2) The CO_2 emissions were calculated by multiplying Used gas volume (Nm^3) and emission factor determined by the ministry of the Environment, Japan