

**Report**

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# **SirkulærPlast: Properties of recycled plastics**

Evaluating the odour properties of refreshed recycled plastics



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## Evaluating the odour properties of refreshed recycled plastics

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## Summary

This study compares malodour in refreshed recycled plastics with virgin materials and attempts to evaluate the refreshment process for recyclates. Broad agreement with previous analytical tests was found by human panels for evaluating the odor of recycled and virgin plastics. Very long refreshment times are necessary to render recycled plastics effectively odourless, although significant odour reduction is achievable in 3-7 hours of refreshment.

# 1 Introduction

Recycled plastics must evidently meet functionality and economic requirements in order to be feasible elements of the plastics market, however a further feature / requirement which could be overlooked is the technical feasibility of their production, and specifically factors relating to occupational health and workplace environment.

Previous work within the SirkulærPlast project has identified malodour as a potential issue for end-products, however it is also clearly a potential issue in production, with the possibility of compromising the working environment and presenting occupational health risks. To investigate odour issues and their possible mitigation, a programme of recyclate “refreshment” was instigated with DePaauw / RODEPA.

In this study we consider the effect of refreshment on recycled PE samples, as a complement to previous analytical testing conducted by Fraunhofer Institute, who performed gas chromatography and measured limonene concentrations (this being identified as a key component for post-consumer recyclates and malodour). Further details on these tests can be found in the Appendix.

## 2 Approach

The evaluation took place in two parts. An initial panel consisting of employees from partner organisations in the SirkulærPlast project initially evaluated samples of recycled polyolefin pellets obtained from De Pauww / RODEPA that had previously been subject to analytical screening. In the second stage of panel testing, a panel was formed from the employees of Østfoldforskning having no connection with the SirkulærPlast project. In this case three additional samples of virgin plastic were also included for comparison. The recycled plastic samples had been “refreshed” for periods between 0 and 22 hours. The samples considered were as follows:

First smell panel:

- Recycled PE refreshed for 0, 3, 5, 7 and 22 hours (following the analytical tests)

All these samples were also considered in the second panel, alongside the following:

- Alternative recycled PE labelled RPE-1
- Virgin HDPE labelled VPE-1
- Virgin HDPE labelled VPE-2

The last two samples contained white-coloured pellets whereas all the others were a dark colour. This was not made obvious to the panel members but was visible. The pellets were placed in identical sample jars marked only with an identifying code known only to the investigators. Panel members evaluated the samples individually, out of sight and earshot of all others. Based on the outcome of the first panel, the approach (in terms of the specific questions asked and the measurements taken) was varied for the second panel, as follows:

- In the first panel, respondents were asked to rank the samples in order of odour intensity. They were then asked to consider which was likely to be the worst “acceptable” sample in a production environment. They were also asked to consider which sample had a comparable odour intensity with virgin material. The RPE-1 sample was available but not as a full member of the sample group; its identity was not concealed, and it was used (openly) for comparison with the recycled samples
- In the second panel, respondents were asked to place the samples on a ten-point scale for odour intensity, where 1 represented sample(s) with the least intense odour and 10 the most intense. The focus was on odour intensity within the range; each respondent was asked to ensure that their responses spanned the full 1-10 range, and multiple samples with the same score were also allowed. This meant that the outcome was more than simply a ranking (as obtained in the first panel), also giving a sense of the magnitude of differences in odour perception between samples.

### 3 Results

In light of the larger panel size, the refinement of the questions asked and the detachment of respondents from the project, one might reasonably assume the second panel to be more definitive than the first. The overall results from both panels were broadly similar.

The results of the first panel are as follows. The shaded cells give the basic rank order of the samples according to each participant, with the number indicating the refresh time of the sample.

Respondent	Least intense		→→→	Most intense		Worst acceptable	Comparable with virgin
	22	7		3	0		
1	22	7	5	3	0	5	5
2	22	5	7	3	0	7 or 22	22
3	22	7	5	3	0	5	None
4	7	22	5	3	0	3	7 or 22
5	22	7	5	3	0	7 or 22	22
6	5	7	3	22	0	Don't know	5

The results show that five of the six respondents ranked the samples in terms of the odour intensity one would expect given the refresh time. Respondents 1, 3 and 5 did so exactly, and respondents 2 and 4 did so except for a single swap between two samples. The outcomes for worst acceptable sample and comparability with virgin material were less equivocal. All respondents agreed that the unrefreshed recycled sample gave the most intense odour and none of them deemed this acceptable and/or comparable with virgin material, but otherwise there was a spread of opinion.

The results for the second panel were as follows:

Respondent	Refreshed recycled PE					Alternative recycled PE	Virgin PE	
	22 h	7 h	5 h	3 h	0 h		RPE-1	VPE-1
1	2	2	3	6	10	3	5	1
2	2	2	4	7	10	1	8	1
3	2	3	3	5	10	3	6	1
4	1	2	2	3	10	1	6	3
5	2	9	6	6	10	3	8	1
6	1	2	1	9	10	2	8	1
7	1	2	2	4	10	2	9	1
8	1	3	1	4	10	1	9	1
9	1	2	3	5	10	1	5	2
10	7	3	7	8	10	1	5	3
11	1	1	2	3	10	3	1	1
12	1	2	2	6	10	1	3	1
13	1	5	3	7	10	1	9	3

14	2	4	4	8	10	1	7	5
15	2	4	5	8	10	1	8	2
16	1	3	3	7	10	1	9	2
17	1	1	1	3	10	1	6	1
Average	1.71	2.94	3.06	5.82	10.00	1.59	6.59	1.76

Much like the smaller first panel, with the occasional outlying result there appears to be a fairly remarkable level of consensus regarding the odour intensity of the samples. The main findings are as follows:

- The rank order of recycled material samples, as manifest in the average odour intensity assessment across the panel, closely corresponds with the refresh time.
- The 22-hour refreshed sample is almost odourless and the unrefreshed recycled sample is the most odour intense by far.
- “Comparability with virgin material” is not necessarily a reliable metric, as virgin materials can vary considerably in their odour intensity

## 4 Discussion and conclusions

The previous analytical results showed a sharp drop in limonene concentration over the first few hours of recyclate refreshment (an order of magnitude decrease after 3 hours and a decrease by a further factor of 4 after 5 hours). The GC results suggested a virtual elimination of odorous compounds after 5 hours, with a sharply decreasing return for longer refreshment periods.

The odour panel results certainly show that more refreshment of the recyclate reduces odour, but the efficiency of the process is painted in a slightly less clear or optimistic light than the analytical results would suggest. PE after 3 hours of refreshment still carries very significant odour according to the panel, and even after 5 hours the panel report significantly more odour than the fully refreshed recyclate or the virgin samples that can effectively be regarded as odourless.

It is hard to gauge what might be acceptable levels in a production environment, particularly as temperatures of the materials are elevated compared to the cold, room-temperature state of the smell panel tests. However, it seems obvious that the unrefreshed recycled sample is unacceptable in terms of odour, and to achieve a very significant reduction in this takes at least 5 hours of refreshment, anything less than this is unlikely to yield an acceptable result.

The refreshment technology is capable of delivering essentially odourless material, that compares favourably with the “best” recycled or virgin material in terms of odour intensity; this requires the full 22-hour refreshment cycle. A later inspection of the recycled samples in the production environment suggested that workers regarded samples refreshed for less than 22 hours to be unacceptable.



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