FUNGAL DEGRADATION OF LIGNIN-BASED RIGID POLYURETHANE FOAMS

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Introduction

✓ The environmental impacts arising from the use of polymeric materials is a serious problem since they can present long periods of degradation and hence being accumulated in the environment.

✓ Polyurethanes (PU) are considered as one of the most versatile polymeric materials offering a wide range of products with applications in diverse sectors. Rigid polyurethane (RPU) foams, due to its excellent insulation and mechanical properties, are widely used in construction, automotive, freeze industry and nautical applications. In this context, the use of green polyols with value-added properties, such as biodegradability, will contribute to reduce environmental impacts.

✓ In this work the ability of *Aspergillus niger* to degrade lignin-based RPU foams in comparison with a control (RPU foam based on a commercial polyol), was tested according to various procedures.

Fig 1 . Polyurethane applications.

Materials and Methods

✓ **Test samples**:

Two RPU foams "**Indulin AT**" and "**Alcell**" (named as the technical lignins used to produce the lignin-based polyols by oxypropylation [1]). A RPU foam "**Commercial**" based on a commercial polyether polyol (Lupranol ® 3323) was used as control. Samples were cut into blocks (6.0x6.0 mm and 2.0 mm thickness) and weighted before being tested.

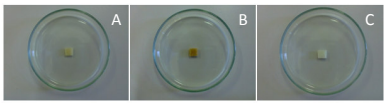

Fig 2 . Foam samples: (A) Indulin AT, (B) Alcell and (C) commercial.

✓ **Biodegradation assays**:

(i) **Degradation on agar plates**, by sample inoculation with *Aspergillus niger* (ATCC 16404) on a nutrient agar plate and incubation during 28 days/30ºC; (ii) **Respirometry in liquid-media** (ISO 14852:1999 with modifications) and (iii) **Respirometry/soil assays** (ISO 17556:2003, with adaptations). In (ii) and (iii) a series of batch cultures were incubated at 30 ºC and the CO_2 produced was periodically monitored during 90 days by titration ($2\ NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$).

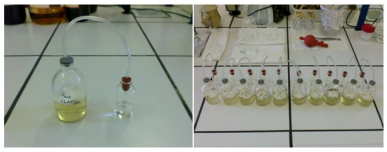

Fig 3 . Respirometry in liquid-media assay set-up.

Results

Biodegradation on agar plates

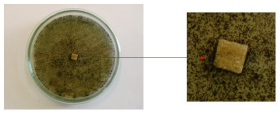

Fig 4 . Agar plate test of Alcell foam with *A. niger* after 28 days.

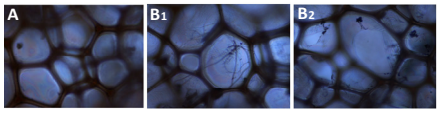

Fig 5 . Optical microscopy images (100x) of the agar plate test for Alcell foam (A): non-inoculated and (B): after inoculation with *A. niger* and incubation (28 days/30 ºC).

✓ *A. niger* was used due to its reported capacity to degrade flexible PU foams [2].

✓ Visual observations allowed verifying the fungi growth on foams surface and the appearance of fungi spores both in the surface and interior (Figure 4) .

✓ After 28 days, it was possible to detect the presence of hifae and spores in the RPU foam cells observed by optical microscopy (OM) (Figure 5).

Respirometry in liquid-media

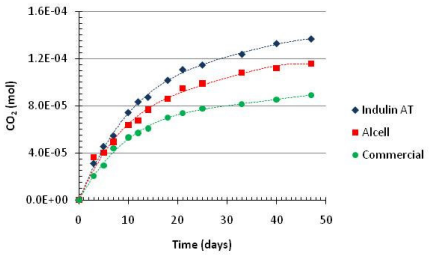

Fig 6 . Respirometry in liquid-media using diluted nutritive broth (1:1000) inoculation with *A. niger* and incubation (47 days /30 ºC).

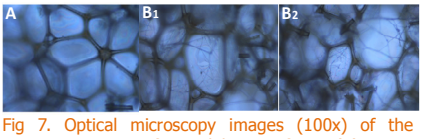

Fig 7. Optical microscopy images (100x) of the respirometry test for Indulin AT foam (A): non-inoculated and (B): after inoculation with *A. niger* and incubation (60 days /30 ºC).

✓ Indulin AT was the foam who presented a higher CO_2 production, followed by Alcell and finally by the commercial foam (Figure 6).

✓ In the OM visualization of the foams, the presence of fungi hifae was observed and degradation was evidenced by changes in the cell wall structures, with surface irregularities, small holes and cracks (Figure 7).

Respirometry in solid-media

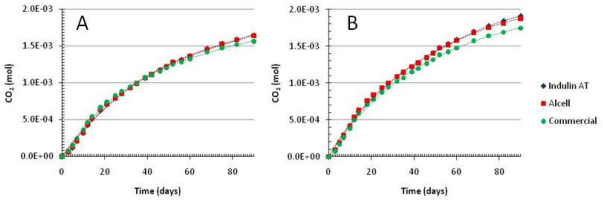

Fig 8 . Respirometry in solid-media without (A) and with (B) *A. niger* inoculum addition

✓ Among the tested foams, the commercial one presented the lowest biodegradation level (in both assays - with and without inoculum addition) .

✓ Biodegradation increased in the assay added with *A. niger* inoculum, specially in the case of lignin-based foams (Figure 8).

Conclusions

✓ The information concerning microbial degradation of PU in the environment is still limited.

✓ In this study, complete polymer biodegradation did not occurred, but PU foam degradation by *A. niger* fungi was observed.

✓ Comparatively to the commercial foam, both lignin-based PU foams presented higher degradation level.

References

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