Designed Polymeric Resins for Selective Separations in Food and Pharma

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Introduction

Designed polymers are a class of selective resins with engineered selectivities for particular target molecules or 'classes' of molecules. These designed polymers are obtained by careful tuning of their surface chemistry and morphology which allows them to exhibit unique separation capabilities. The tailored and optimized selectivity of designed polymers is utilized to conduct difficult separations that are not able to be accomplished with conventional separation resins or other techniques.

Benefits of Designed Polymers

As a novel technology, designed resins may offer a series of potential advantages, such as:

Separation power

Designed polymer may enable the resolution of difficult-to-separate compounds or a targeted extraction.

Higher Productivity

Tailor-made polymeric resins may allow larger process volumes to be purified per mass of adsorbent.

Safer Solvents

By choosing an optimal adsorbent, the use of flammable solvents may be reduced or eliminated.

Resin Stability

Our highly cross-linked adsorbents may offer a higher durability in a given process.

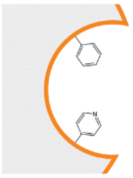
Greener Chemistry

With an optimized separation process, toxic reagents may be reduced and thus contribute to a more environmentally friendly industry.

An extensive range of polymer resins with different designed surface chemistries is availaible at MIP Technologies. This toolbox may offer ready solutions to separation challenges.

RENSA™ PY

MIP Technologies AB has developed the designed resin RENSA™ PY with a novel surface functionality containing both hydrophobic and pyridine moieties (Fig 1).



Properties of RENSA™ PY	
Polymer backbone	Styrenic
Cross-linking degree	~ 50%
Average particle size	100 µm
Pore diameter	~ 50 Å
Pore volume	~ 0.5 mL/g
Surface area	~ 500 m²/g
Surface functionality	Pyridine
Working pH range	1–14
Average swelling	40% (Methanol)
Average density (tapped)	0.3 g/mL

Figure 1. *Schematic illustration of the binding cavity and material properties of RENSA™ PY.*

Two applications with one such novel resin are presented here.

1) The separation of Penicillin G (Pen G) and its degradation products.

2) The fractionation of natural food dyes with only an aqueous gradient.

Separations were done with RENSA™ PY in Biotage columns and run on a Biotage flash system (Fig 2).

Figure 2. *RENSA™ PY packed in Biotage® SNAP columns. Separations were conducted on an Isolera™ Four flash chromatography system (Biotage AB, Sweden).*

Separation of Beta-lactam Compounds

Beta-lactam antibiotics are among the most widely used antibiotics. 6-APA is an important starting compound for a large number of semi-synthetic beta-lactam antibiotics. In Fig 3, the decomposition of Pen G to PAA and the penicillin nucleus 6-APA is shown. Due to the hydrophilic nature of 6-APA, many RP resins display a poor retention (Fig 4) and thus unsatisfactory separations.

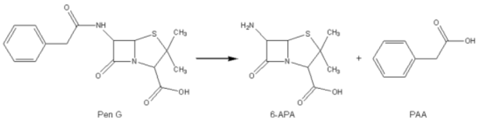


Figure 3*. Pen G and its breakdown products 6-APA and PAA.*

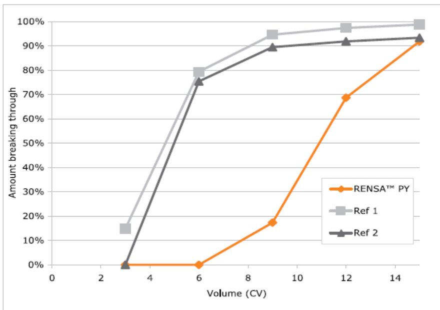


Figure 4. *Breakthrough curves with 6-APA.*

The breakthrough curve in Fig. 4 clearly demonstrates that *RENSA™* PY retains 6-APA much more efficiently (to up to 6 CVs) compared to benchmark RP materials 1 and 2 which are not able to retain more than 3 CVs.

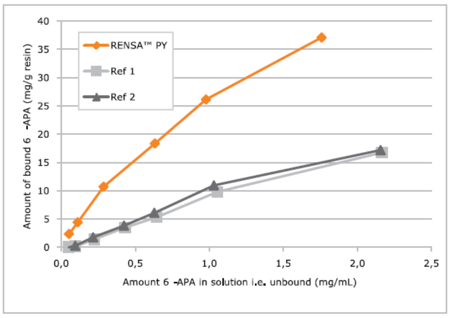


Figure 5. *Isotherms for 6-APA at various concentrations.*

In addition, the isotherms in Fig 5 demonstrate the higher capacity of RENSA™ PY towards 6-APA than the benchmark RP resins.

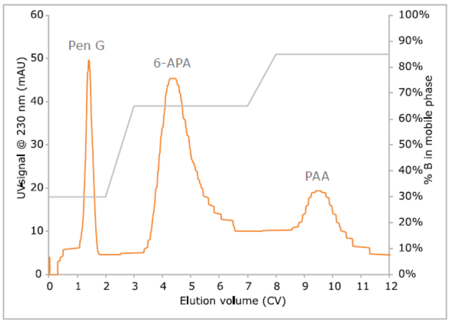


Figure 6. *The chromatogram shows the successful separation of Pen G, 6-APA and PAA on RENSA™ PY using a gradient of water and methanol on an Isolera™ flash chromatography system.*

As seen in Fig 6, the three compounds can be readily separated using a simple methanol gradient. Compared to conventional RP materials based on styrene, RENSA™ PY has a much more pronounced retentivity towards hydrophilic compounds such as 6-APA and PAA in aqueous media – it can thus accomplish an improved separation. This may allow producers of these or similarly hydrophilic compounds to improve their separation process.

Fractionation of Food Dyes

Many edible plants contain a multitude of color compounds. For example, beetroot contains among others, the natural food color betanine (Fig 7). In this proof-of-concept study, we evaluated the ability of RENSA™ PY to separate the colored compounds in beetroot juice (Fig 8).

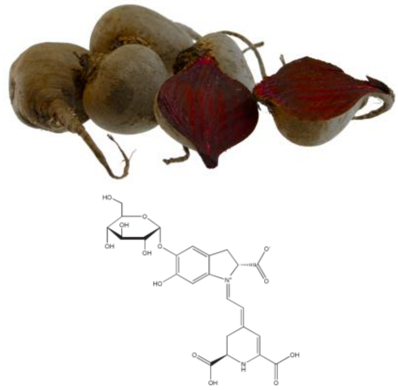


Figure 7*. Fresh beetroot, chemical structure of betanine.*

Betanin is expected to be retained predominantly through electrostatic interactions with the surface pyridine moieties of RENSA™ PY. At pH < 6 retention can occur and at pH > 8, the retention of betanin is reduced.

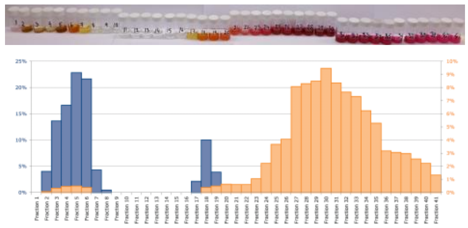


Figure 8. *Analysis of the eluted fractions collected after separation of beetroot juice on RENSA™ PY packed in a Biotage® SNAP column run on an Isolera™ flash chromatography system. Orange bars show quantification of betanin at 535 nm, blue bars represent other colored compounds at 480 nm.*

This proof-of-concept investigation demonstrates that RENSA™ PY can separate betanin in an aqueous beetroot juice and fractionate the dye compounds to obtain a fraction of a desired dye type. The process conditions are mild and the beetroot juice is only exposed to a slightly elevated pH during a short period of time.In contrast, reversed phase resins based on styrene typically do not display sufficient retention of the highly polar betanin. Any retention of betanin by reversed phase interactions needs to be eluted off with organic solvents. The use of strong ion exchangers is in principle also possible, but requires high amounts of salts to elute off bound betanin. Neither highly concentrated salt gradients nor organic solvents are required for this dye separation using RENSA™ PY.

Conclusions

- RENSA™ PY is a new type of resin with increased retentivity towards different polar substances.
- RENSA™ PY is able to retain 6-APA better than conventional RP resins.
- RENSA™ PY can also separate natural food juice into interesting fractions.
- MIP Technologies has a broad series of novel designed resins.
- MIP Technologies has a successful track record of working closely with clients towards the solution of challenging separation tasks.

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