Reactor Technology With Additively Manufactured Packings

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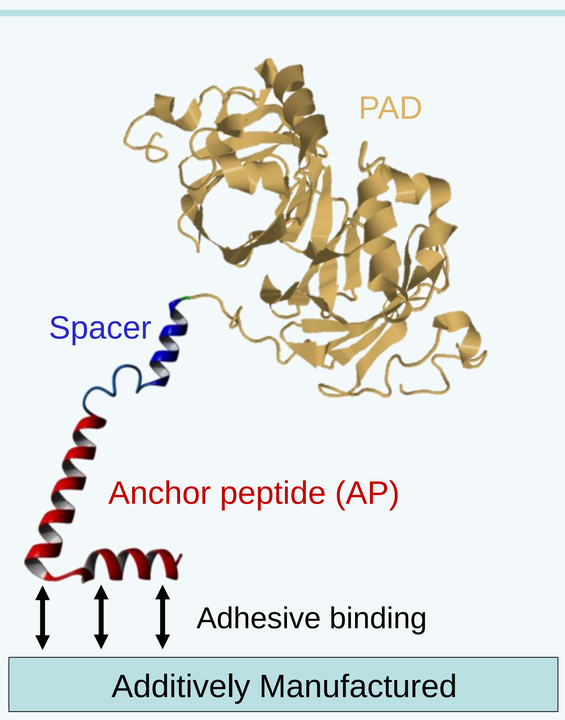
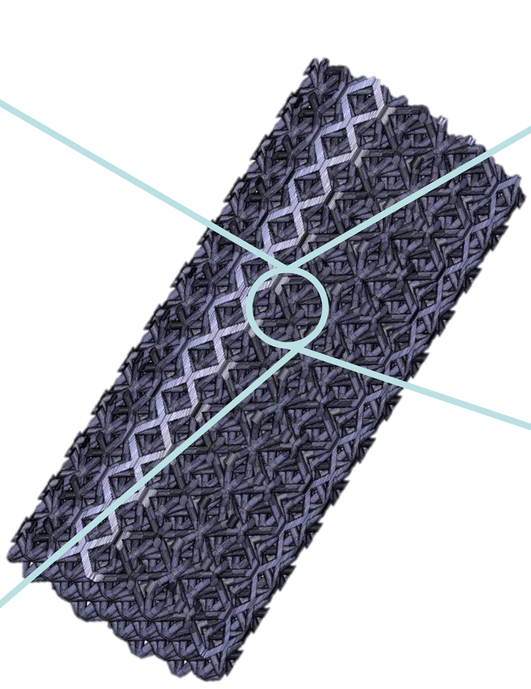
Additively Manufactured Packings in Biocatalysis

Immobilisation on Packings



- Different anchor peptides for selected surfaces
- Covalent attachment of anchor peptide to phenolic acid decarboxylase (PAD) as cell-free-extract (CFE)
- Strong reversible adhesive binding

Additively Manufactured Packings



- Additive manufacturing (AM): creation of novel structures in a fast and easy way.
- Periodic open cell structures (POCS) as static mixers in multi-phase flow reactors
- Selected materials: polyethylene terephthalate (PET), AlSi, Ti6Al4 and stainless steel 14.404

Mass transfer in biphasic system

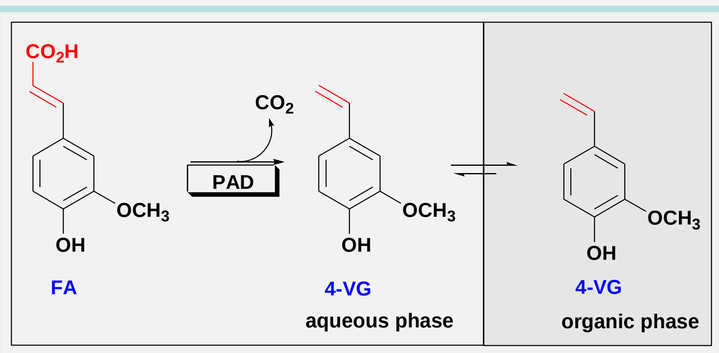
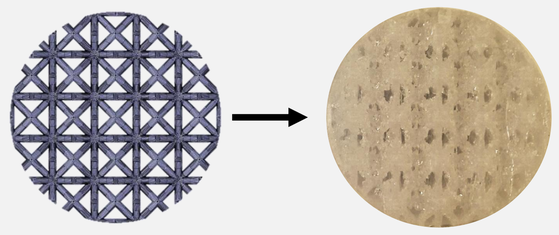


Fig. 1: Decarboxylation of ferulic acid FA in 0.5 M KP_i buffer (pH 7) and *in situ* product extraction with *n*-heptane as organic solvent[1]



- Reaction and extraction with AM POCS
- Biphasic system for *in situ* product removal
- Selected organic solvent as the second phase: *n*-heptane
- High interfacial area and reaction rate ensured by optimum flows

Potential of Additively Manufactured Packings

Immobilisation on packing material

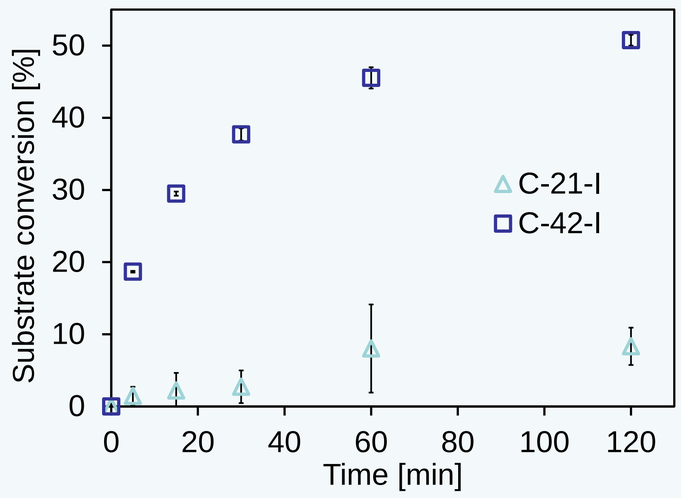


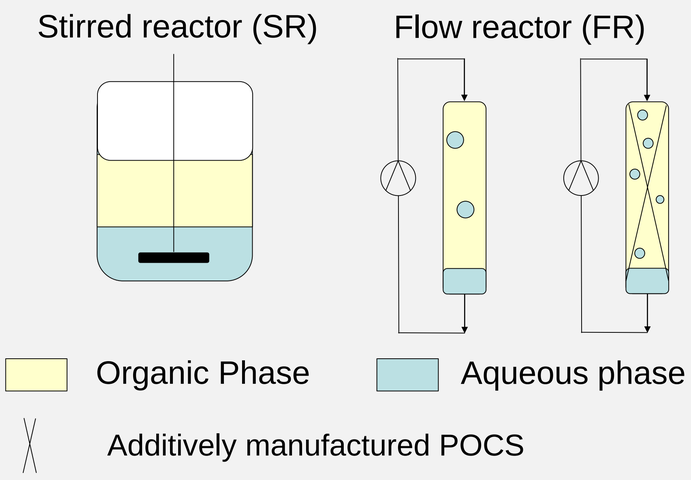
Fig. 2: Conversion of 1 mL 5 mM substrate solution in KP_i buffer (0.5 M, pH 7) with 0.5 g PET-Immobilisates (d<300µm, 0.344m²/g) with two different PAD-Anchor constructs shaken in HPLC vials. T=37 °C, n=700 rpm

Tab. 1: Obtained initial surface specific activities

Parameter	C-21-I	C-42-I	Unit
Area specific activity	0.02	1.01	U/m²

- Material chosen: PET
- Negative control: PAD without anchor
- Conversion is limited
- Two promising anchors identified

Extraction in Batch mode



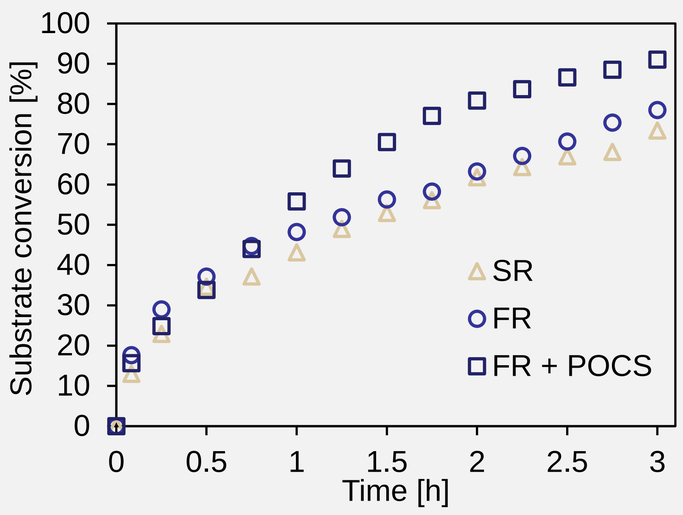


Fig. 2: Conversion of 6 mL 100 mM substrate solution in KP_i buffer (0.5 M, pH 7) and 12 mL heptane in three different reactor set ups.

Tab. 2: Conditions in experimental set up: comparison of in situ extraction within three different reactor types (SR, FR, FR + POCS).

Parameter	SR	FR	Unit
Substrate concentration	100		mM
Temperature	37		°C
Stirring speed	400	-	1/s
Volume flow	-	5	mL/min
Aqueous volume	6		mL
Organic volume	12		mL
Used CFE	1		mL

- Conversion after 1.75 h in FR with POCS 21% higher than without POCS
- Less product accumulation in aqueous phase

Conclusion

- Adhesive immobilisation on additively manufacturable materials possible
- Installation of POCS in flow reactors can improve mass transports in biphasic systems

Outlook - Evaluation of:

- Other reaction operation conditions
- POCS and bed heights
- Comparison of reactor designs under fixed conditions , e.g. energy input

References:
[1] L. Pesci, M. Baydar, S. Glueck, K. Faber, A. Liese, S. Kara, *Org. Process Res. Dev.* 2017, 21 (1), 85–93.

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