

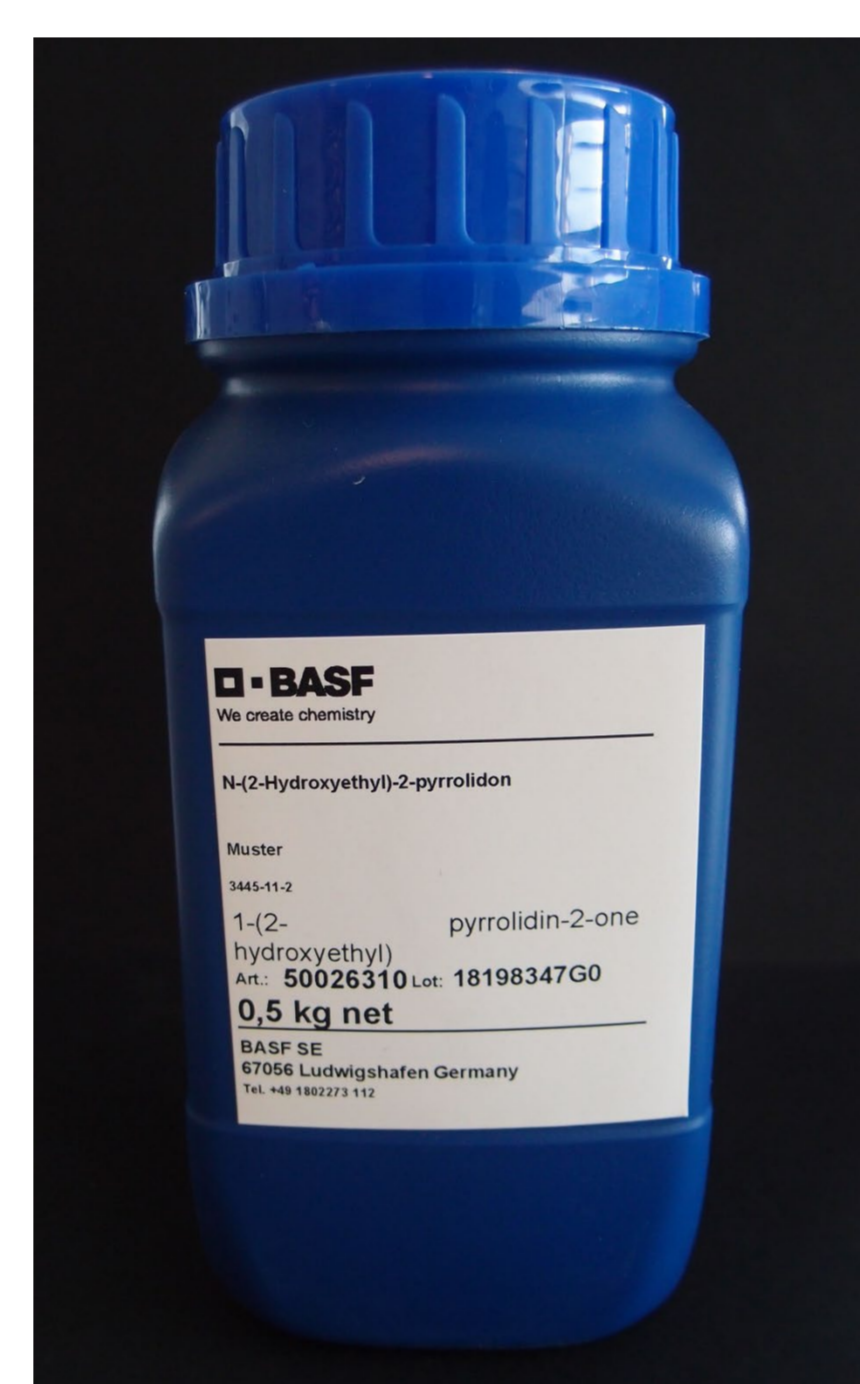
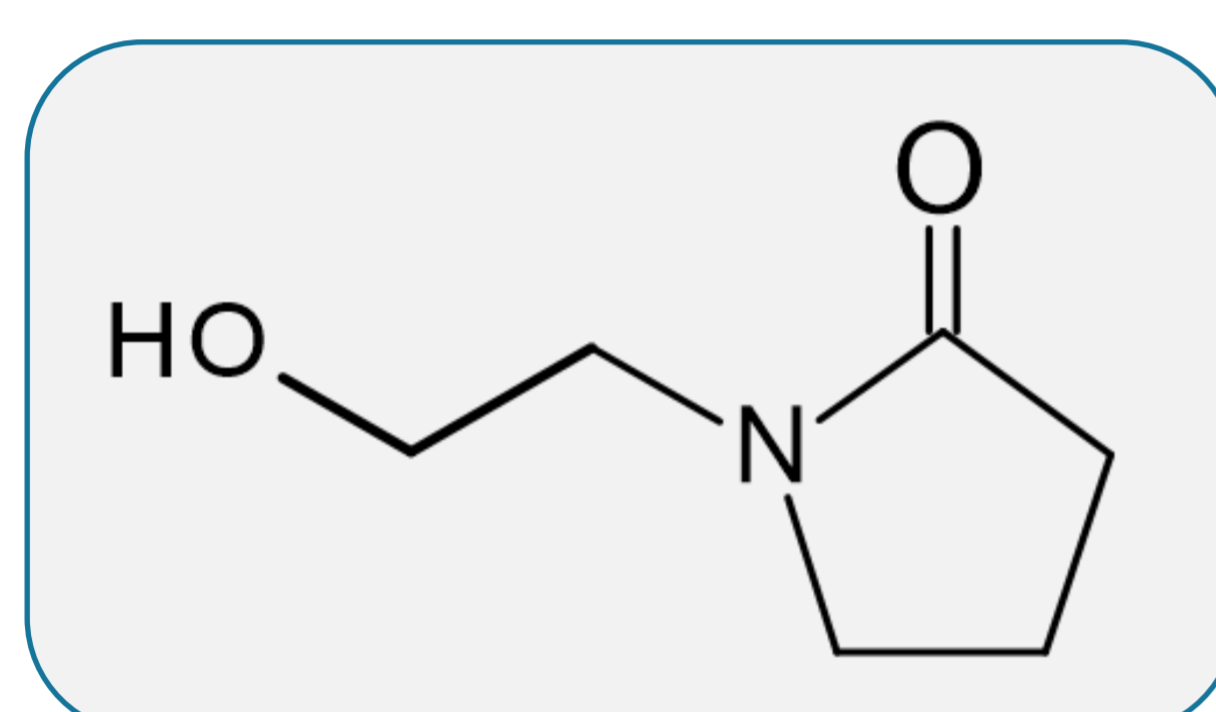
1-(2'-hydroxyethyl)pyrrolidin-2-one as green solvent for poly(ethersulfone) ultrafiltration membrane fabrication

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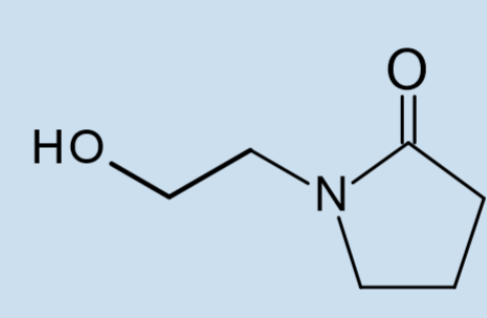
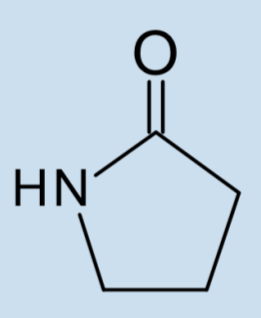
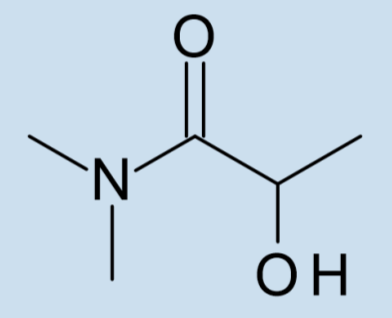
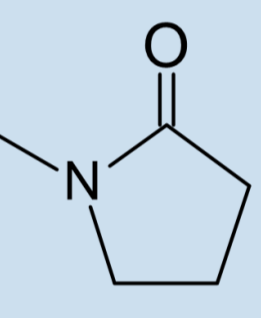
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1-(2'-hydroxyethyl)pyrrolidin-2-one (HEP)

Physical data of polar, protic solvents

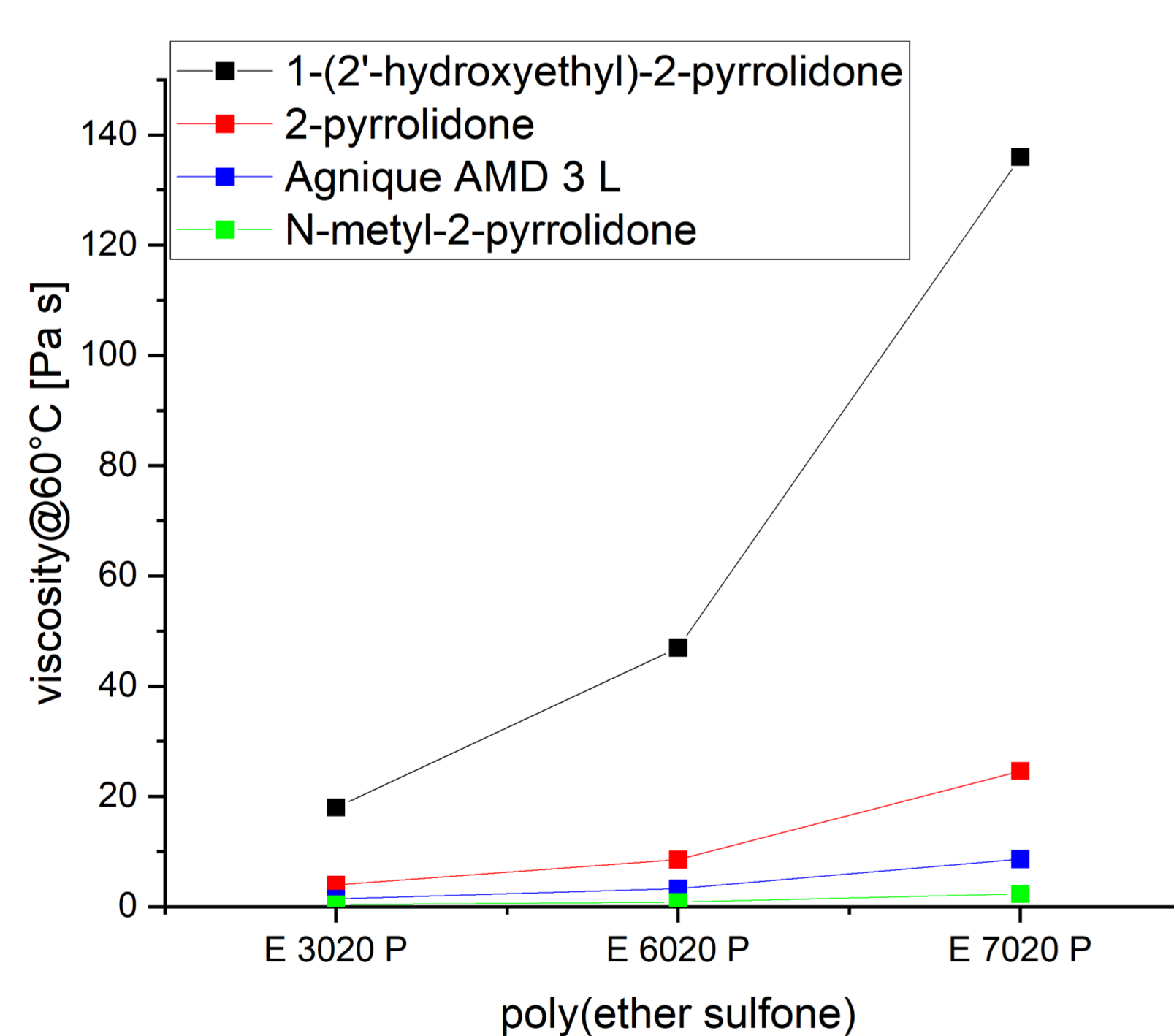


- Polar, protic solvent
- Label free according to GHS, no substance of very high concern (SVHC)
- Commercially available and fully REACH registered up to <10 000 tonnes per annum

	1-(2'-hydroxyethyl)-2-pyrrolidone	2-pyrrolidone	Agnique® AMD 3 L	N-methyl-2-pyrrolidone
Structure				
CAS No.	3445-11-2	616-45-5	35123-06-9	872-50-4
Molar Mass	129.16 g mol ⁻¹	85.11 g mol ⁻¹	117.2 g mol ⁻¹	99.13 g mol ⁻¹
Pour / Melting point	26 °C	25 – 26 °C	- 60 °C	- 23 °C
Flash Point	174 °C	138 °C	103 °C	91 °C
Boiling Point	309 °C	245 – 255 °C	223 °C	204 °C
Density at 20 °C	1.145 g cm ⁻³	1.1 g cm ⁻³	1.046 g cm ⁻³	1.03 g cm ⁻³
Vapor pressure at 20 °C	0.0002 hPa	0.0004 hPa	< 0.1 hPa	0.32 hPa
Viscosity at 25 °C	77.2 mPa s	16.4 mPa s	5.1 mPa s	1.89 mPa s
Solubility in water	miscible	miscible	miscible	miscible
GHS classification	no hazard label	H319, H360D	no hazard label	H315, H319, H360D
SVHC substance	no	SVHC	no	SVHC

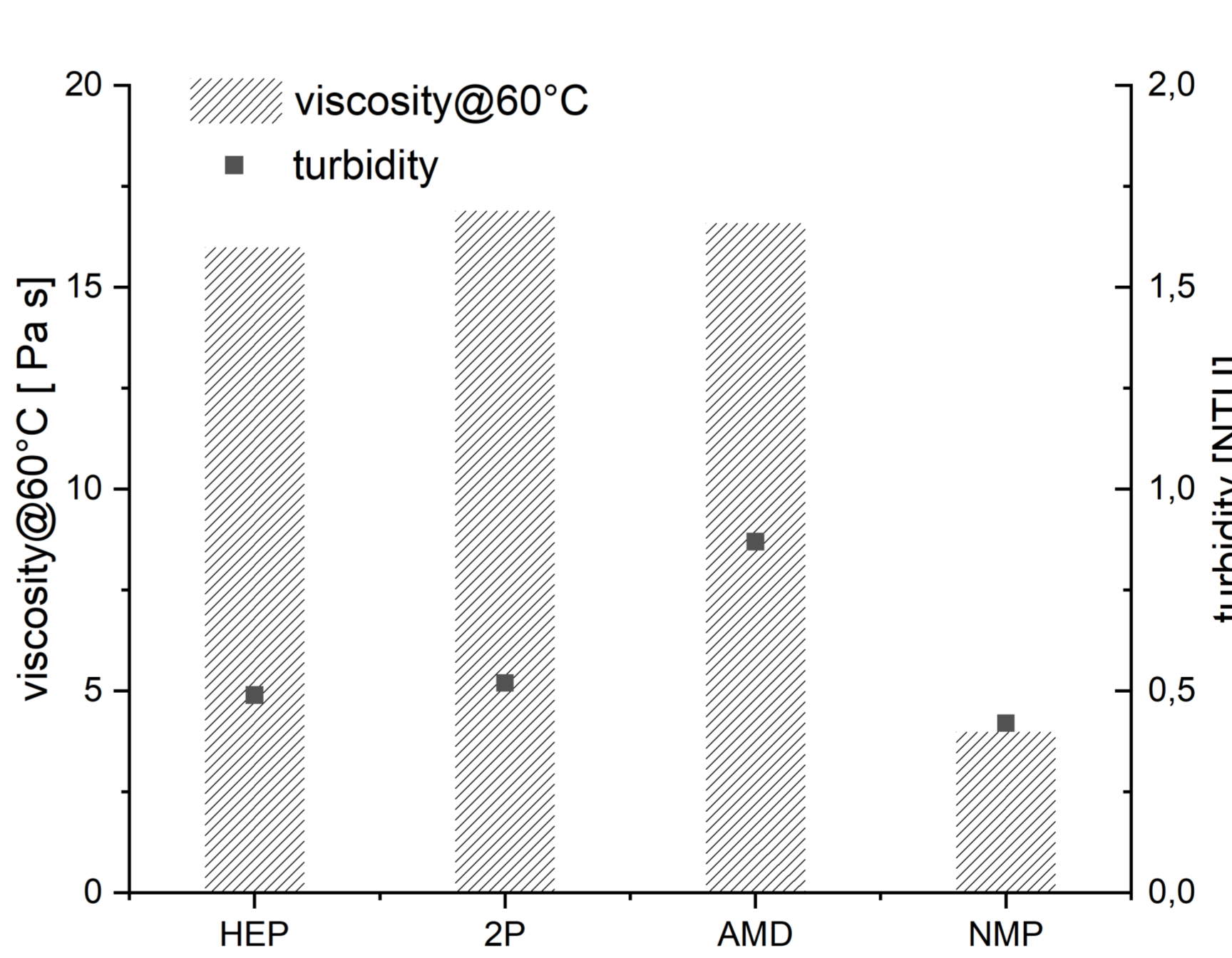
GHS: globally harmonized system; SVHC: substance of very high concern

PESU solution viscosity



- 20wt% solution with poly(ether sulfone)
- Different Ultrason® E grades:
 - Ultrason® E3010 M_w (GPC): 52 kDa
 - Ultrason® E6020 P M_w (GPC): 72 kDa
 - Ultrason® E7020 P M_w (GPC): 90 kDa
- Solution viscosity ranking: HEP >> 2P > AMD > NMP

PESU dope composition properties

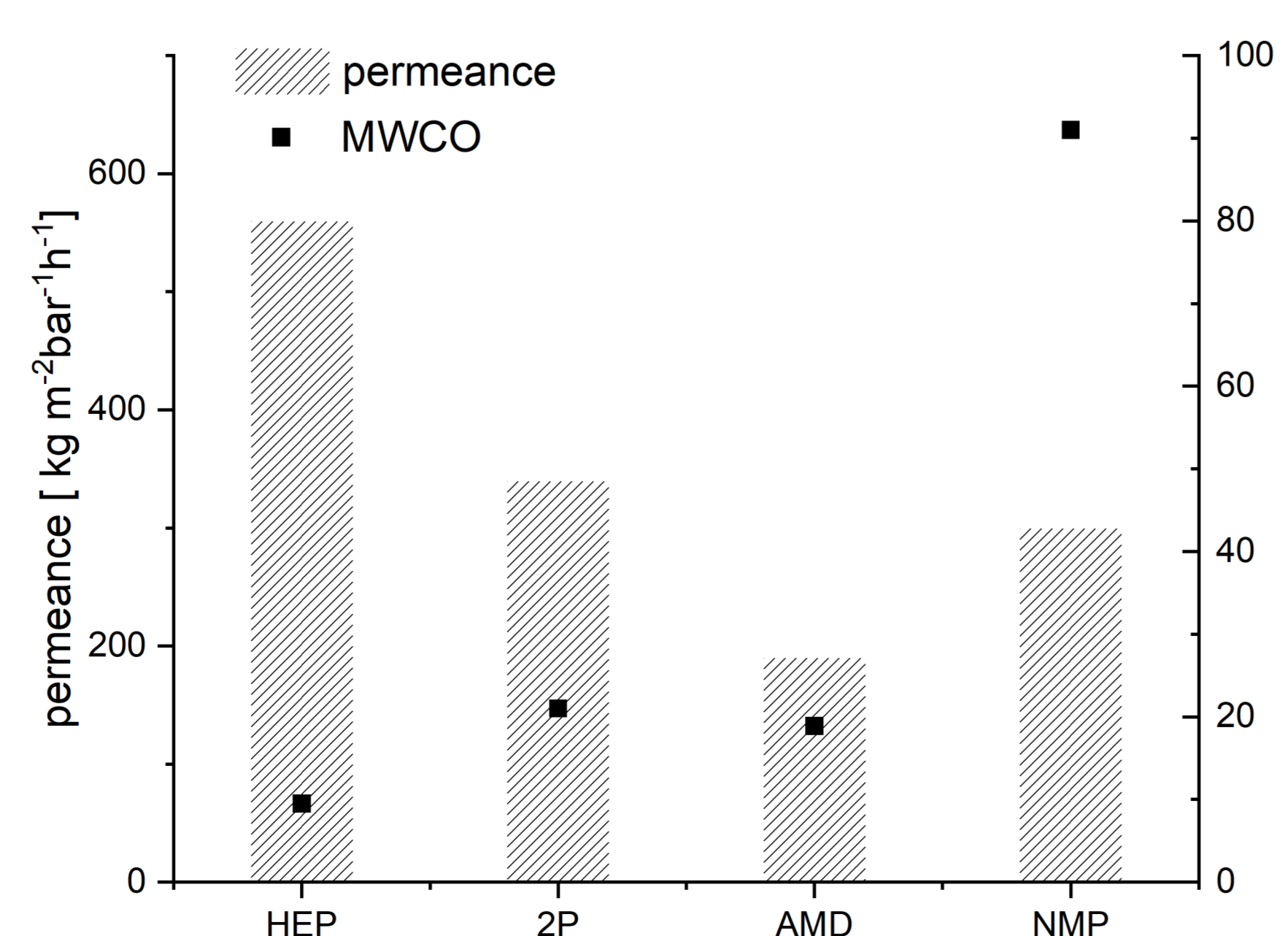
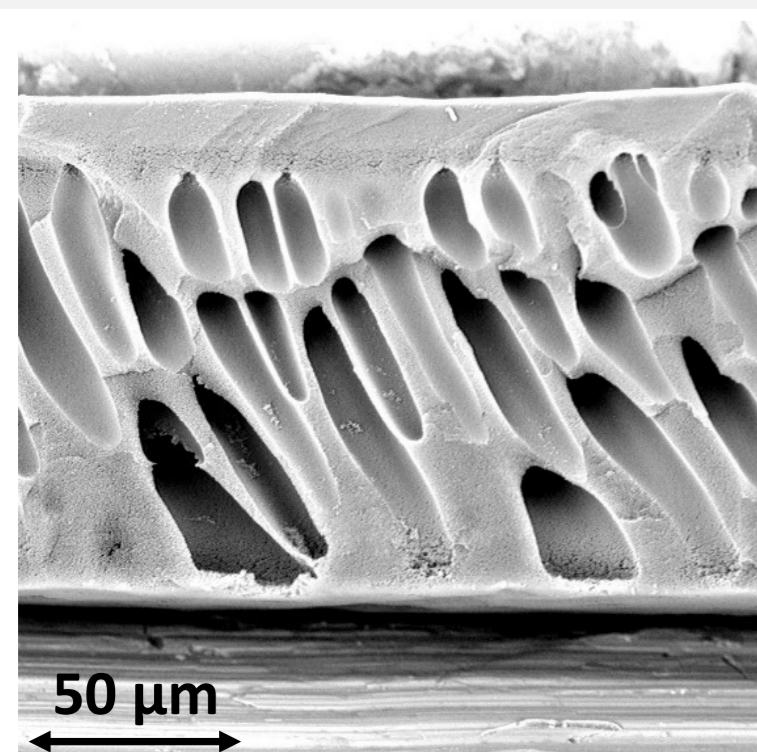


dope	K17 [wt%]	K30 [wt%]	K85 [wt%]	K90 [wt%]
HEP	5	---	---	---
2P	---	2.5	2.5	---
AMD	---	---	5	---
NMP	---	---	---	5

- 15 wt% E6020P, 80 wt% solvent
- 5 wt% PVP of different grades:
 - Luvitec® K17 M_w (GPC): 9 kDa
 - Luvitec® K30 M_w (GPC): 50 kDa
 - Luvitec® K85 M_w (GPC): 1100 kDa
 - Luvitec® K90 M_w (GPC): 1400 kDa
- Except for NMP similar solution viscosities and turbidities adjusted

PESU UF membrane properties

- NIPS flat sheet membrane fabrication
- Coagulation bath: water/solvent 4/6 wt/wt
- Post treatment: water wash 60°C
- Tighter membranes with higher permeance from HEP solutions



SEM cross-section HEP PESU membrane (1500 x magnification)

Conclusion

- HEP as polar, protic commercial solvent requires no GHS labelling
- Commercially available and fully REACH registered up to <10 000 tonnes per annum
- PESU solutions in HEP show high solution viscosity values
- PESU ultrafiltration (UF) membrane preparation by NIPS processing:
 - low molecular weight PVP grades can be employed as pore forming additives
 - oxidative post treatment procedures can be omitted
 - compared to 2P, AMD and NMP tighter UF membranes with higher permeance found
- HEP provides a new alternative as replacement for polar, protic and aprotic solvents employed in manufacturing of technical PESU membranes.