Modifying Amine Solvent Properties to Increase CO_2 Mass Transfer

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Approach/Goals

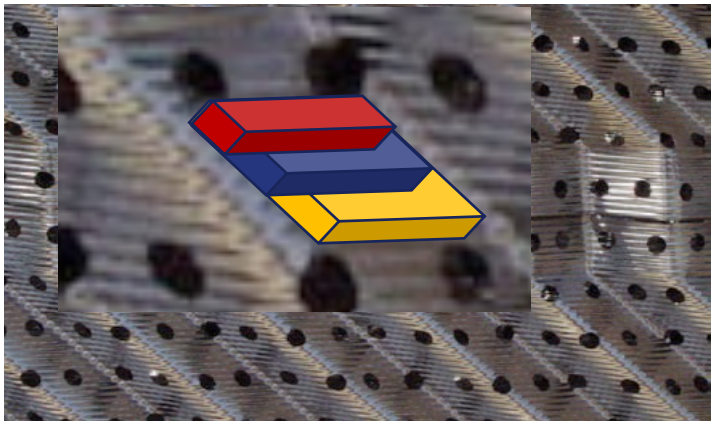
Our current interest is in developing process enhancements and technologies that can be broadly applied to amine-based post-combustion CO_2 capture systems:

A better understanding of solvent physical properties, specifically those related to increasing packing wettability and CO_2 mass transfer

How does packing wettability translate to CO_2 flux?

$$k'_g \propto \frac{\sqrt{D_{CO_2} \cdot k_2 \cdot [AM]}}{H_{CO_2}}$$

$$Flux = k_G \cdot (P^g_{CO_2} - P^*_{CO_2})$$

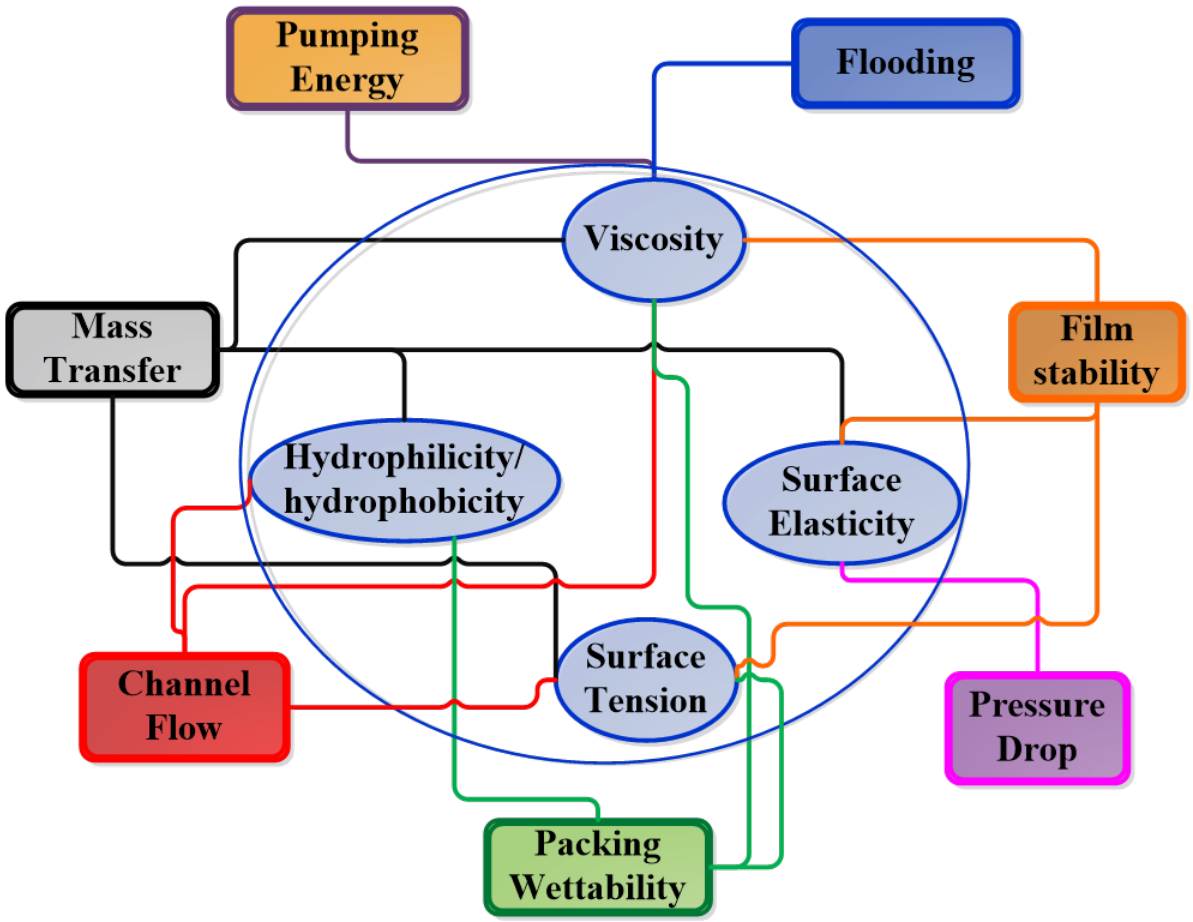


	MEA	PZ	MDEA
Rate Constant	5.94	69.21	0.004
Self-concentrated amine	1.0	3.5	~1
Calculated Kg' impact from [M]	1	1.87	~1
Calculated Kg' impact from k_2	1	3.41	0.03
Calculated Kg' Overall	**1**	**6.39**	**0.03**
Measured Mass Flux (WCC@0.1)	1	2.20	0.18

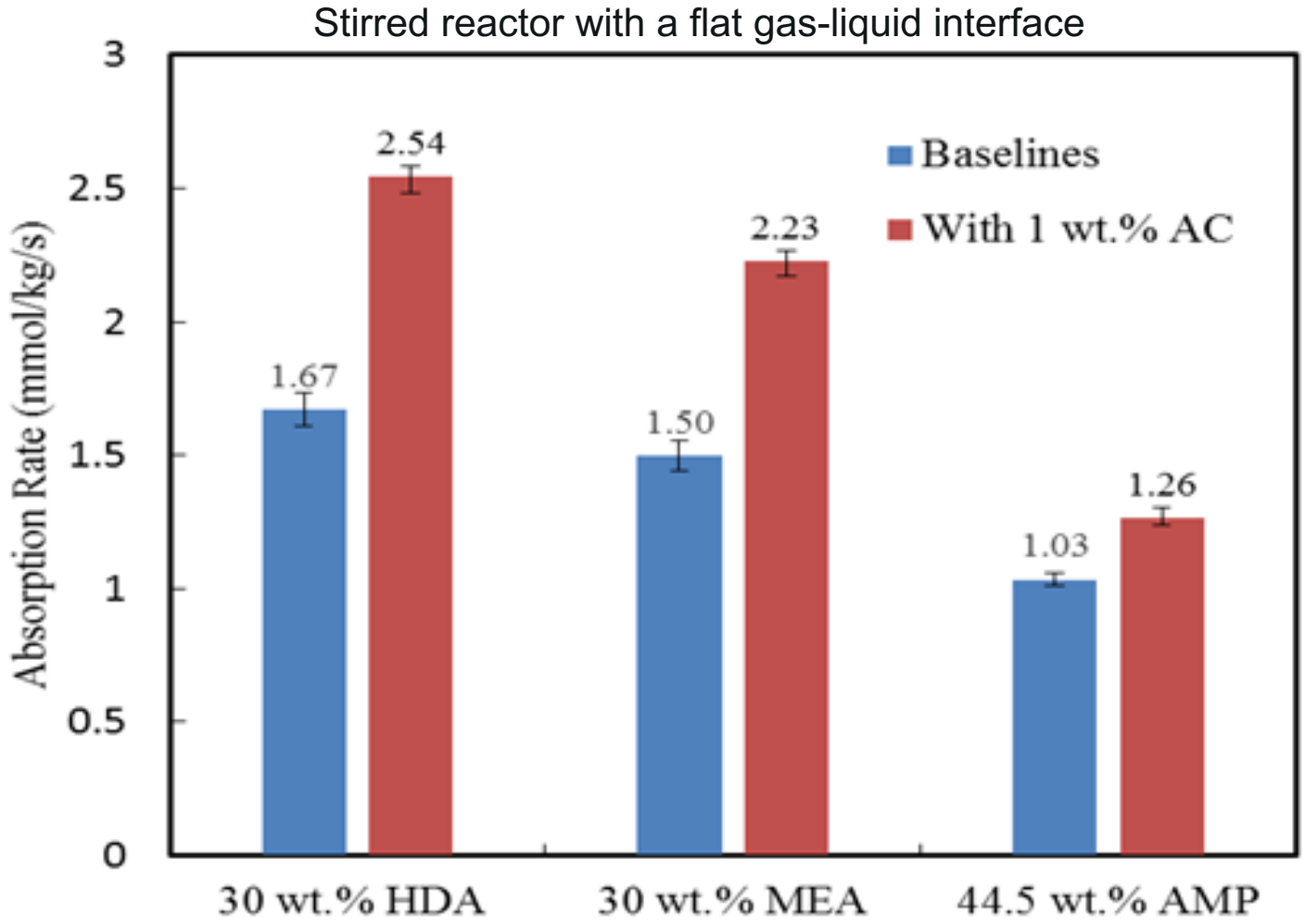
- Most solvents do not take full advantage of packing due to their physical properties, i.e. viscosity, surface tension and contact angle (relative to the packing material)
- Can solvent physical properties be modified to improve CO_2 mass transfer?

Physical Properties of Amine Solvents

- Find ways to modify physical properties of solvents to increase CO_2 mass transfer (decrease diffusion resistance)
- Additives can be used to modify physical properties, including surface tension and contact angle (wettability)



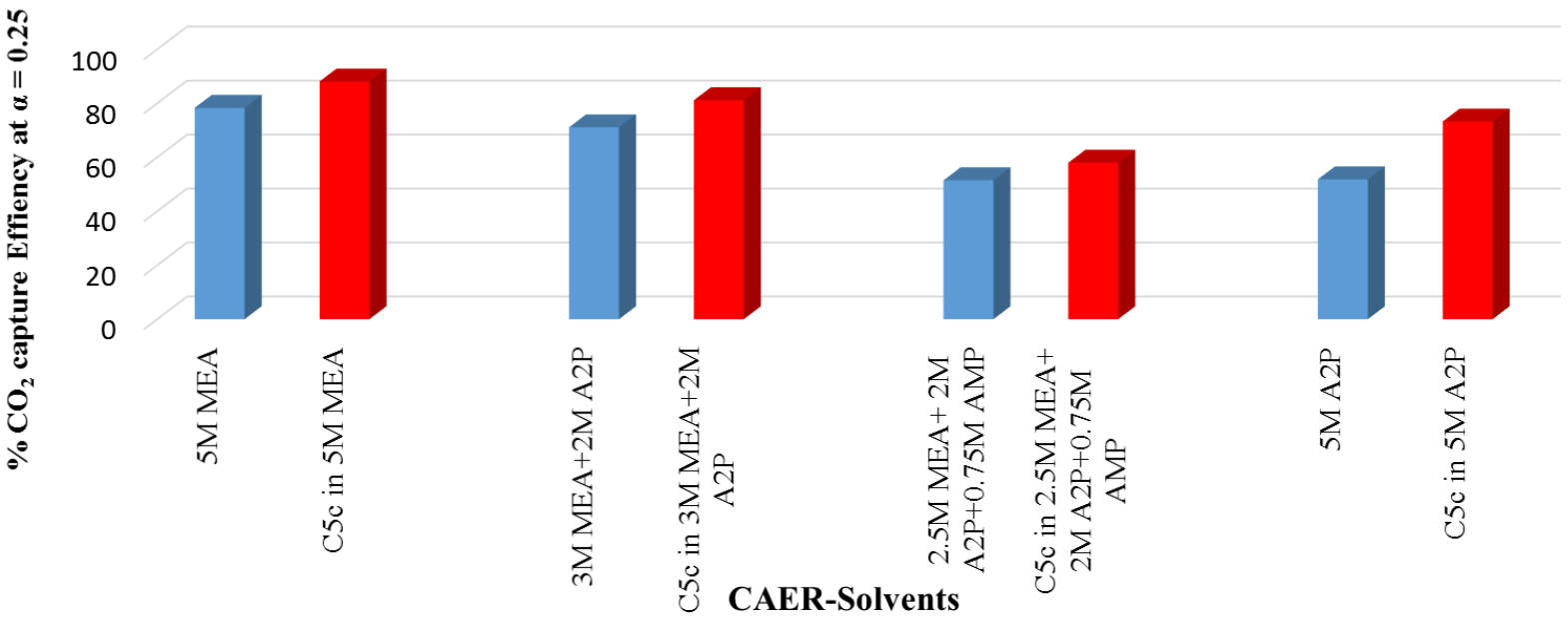
Enhancing Amine Solvents - Additives



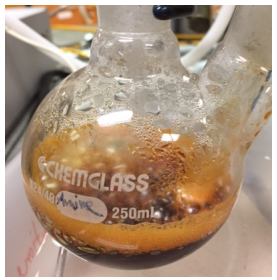
Increased CO_2 mass transfer from addition of small particles (increased bulk mixing)

Mannel et.al. Int. J. Greenh. Gas Control , 2017, 61, 138–145

Enhancing Amine Solvents - Additives



C5c Catalyst in 5M MEA



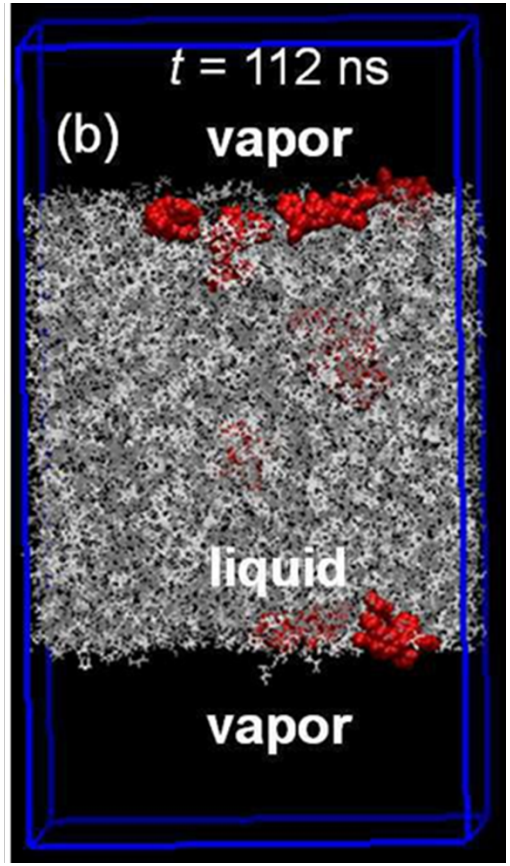
C5c in 3M MEA + 2M A2P

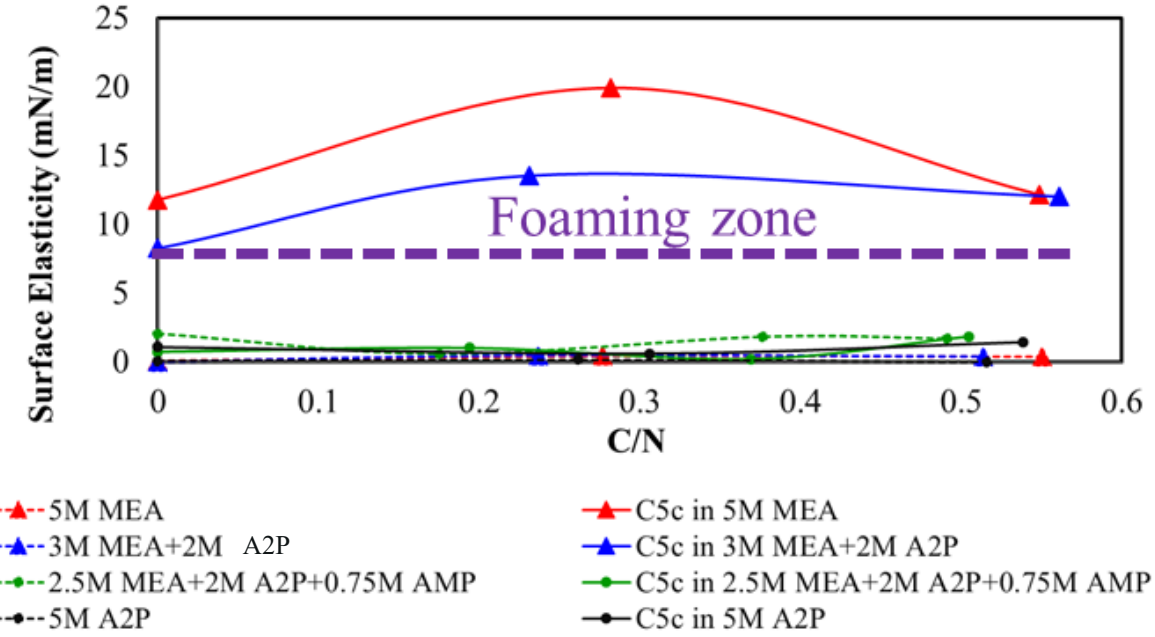
C5c in 2.5M MEA+2M A2P + 0.75M AMP

C5c in 5M A2P

Catalytic enhancement and solvent elasticity can increase of CO_2 mass transfer

Physical Properties of Amine Solvents

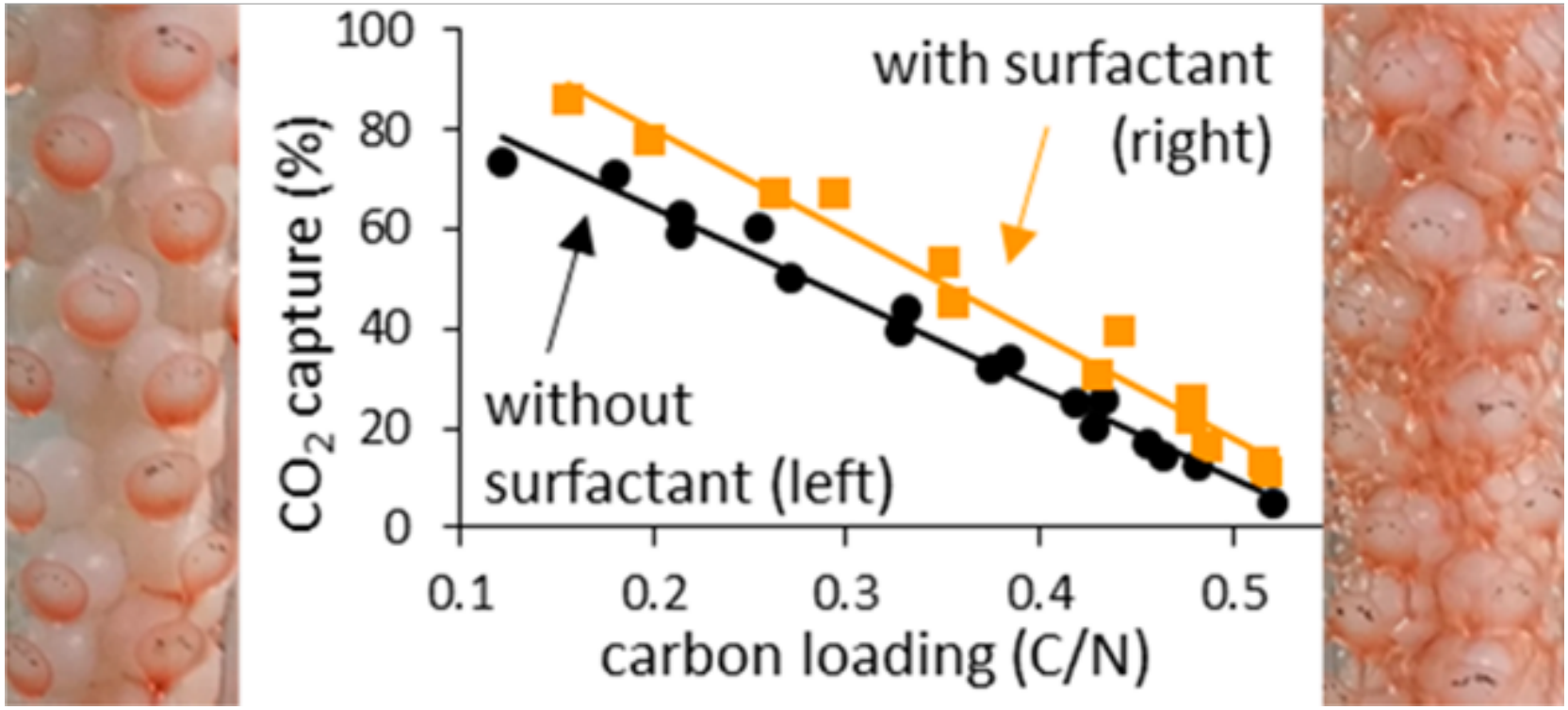




Surface Elasticity seems to determine the foaming behavior of a solution

Computational studies are still ongoing with NETL to better understand the interactions based on structure of the amine and different types of additives

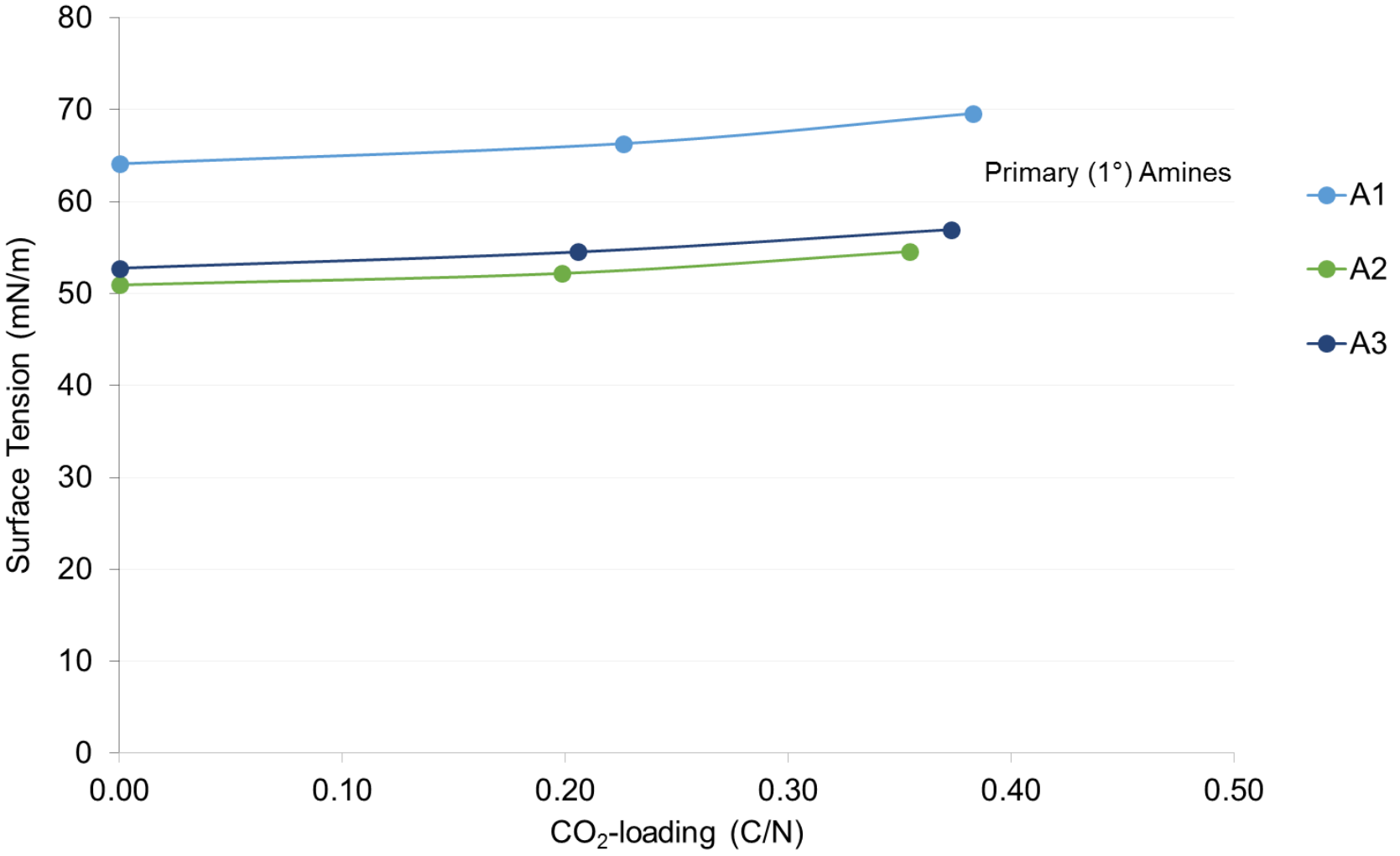
Enhancing Amine Solvents - Additives



Increased CO_2 mass transfer was observed as the result of micro-bubble/froth formation in solutions containing a small amount of surfactant-type additive

Bryant et.al. Ind. Eng. Chem. Res. 2016, 55, 7456–61.

Modify Physical Properties of Amine Solvents



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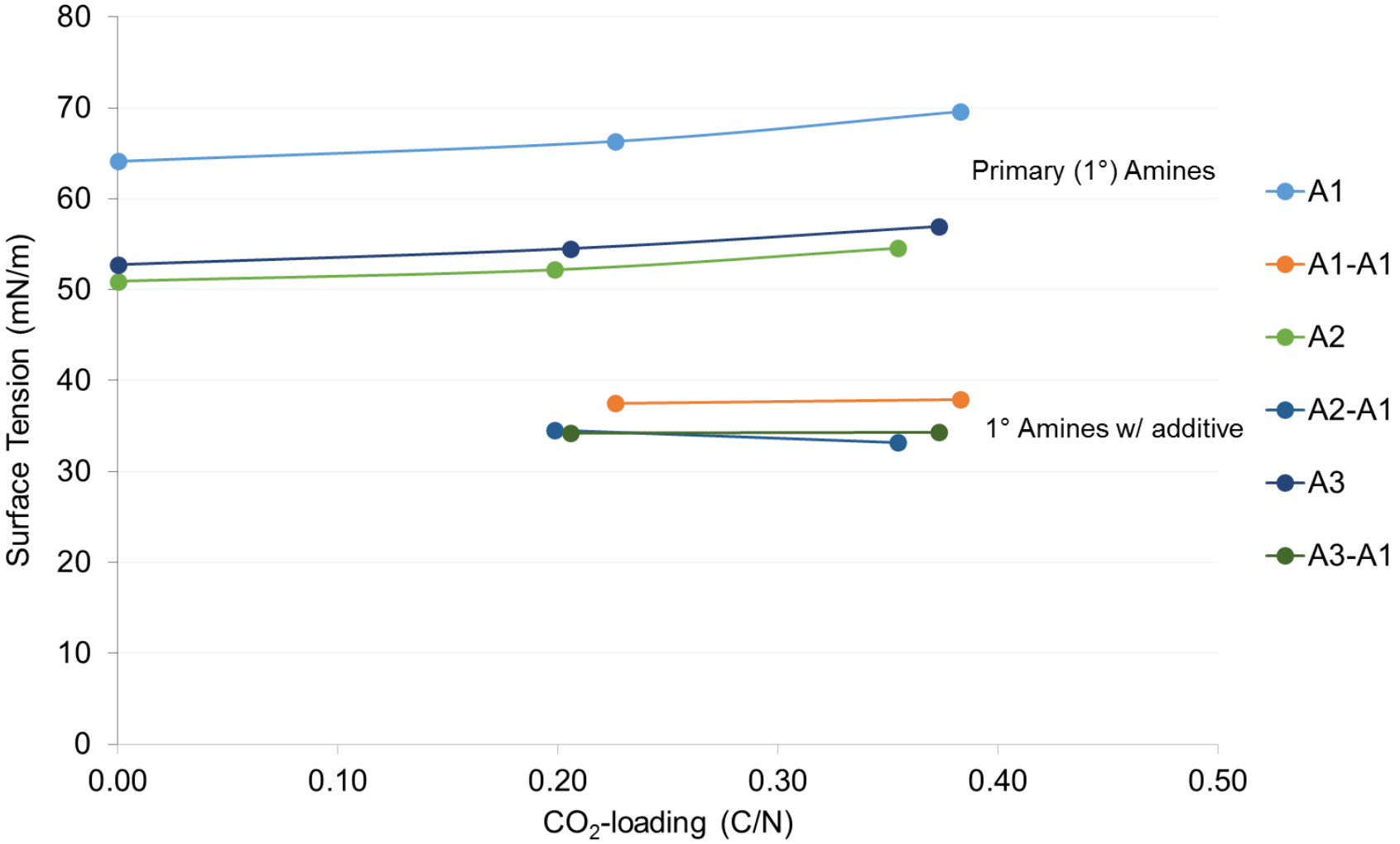

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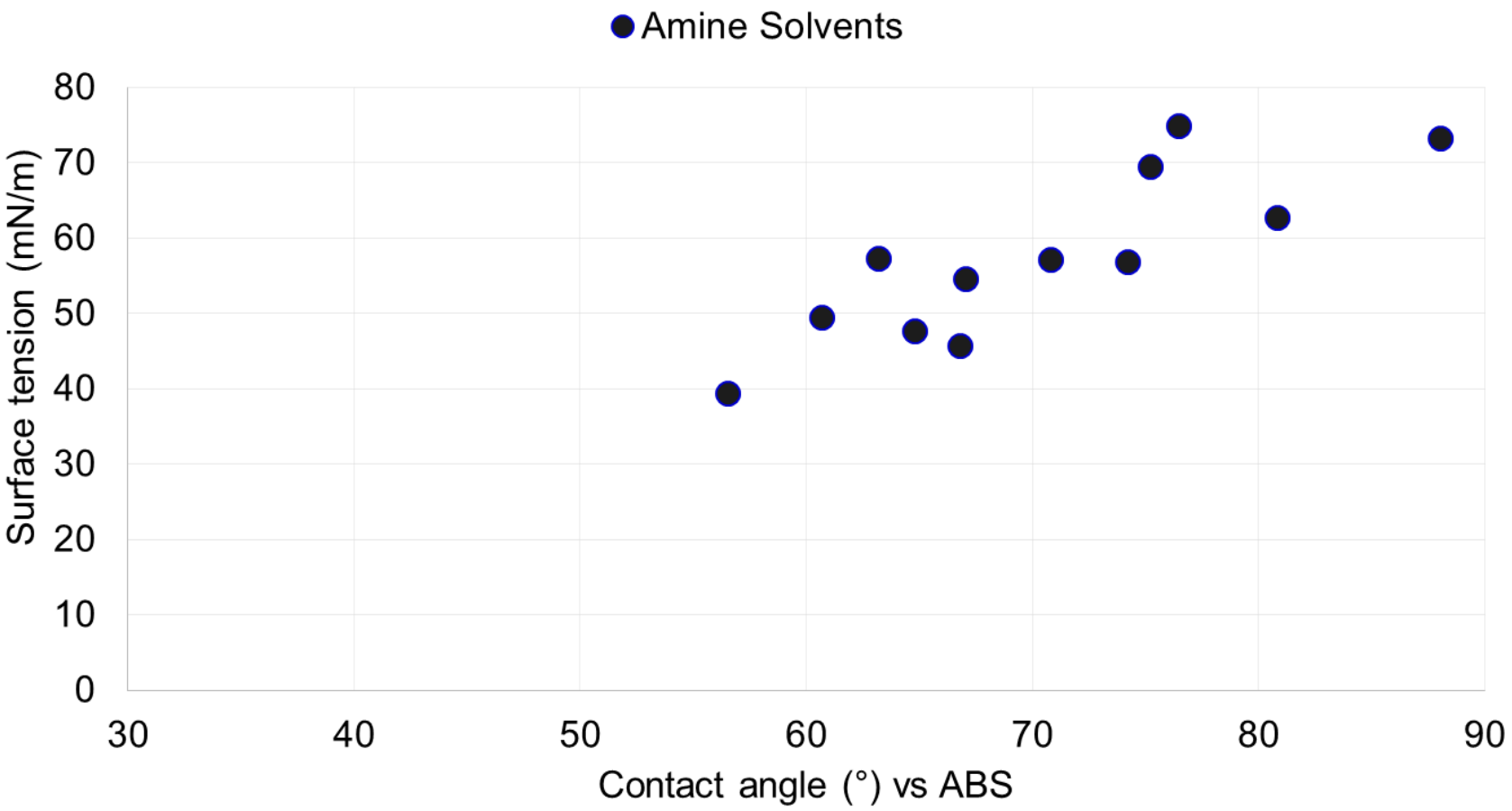

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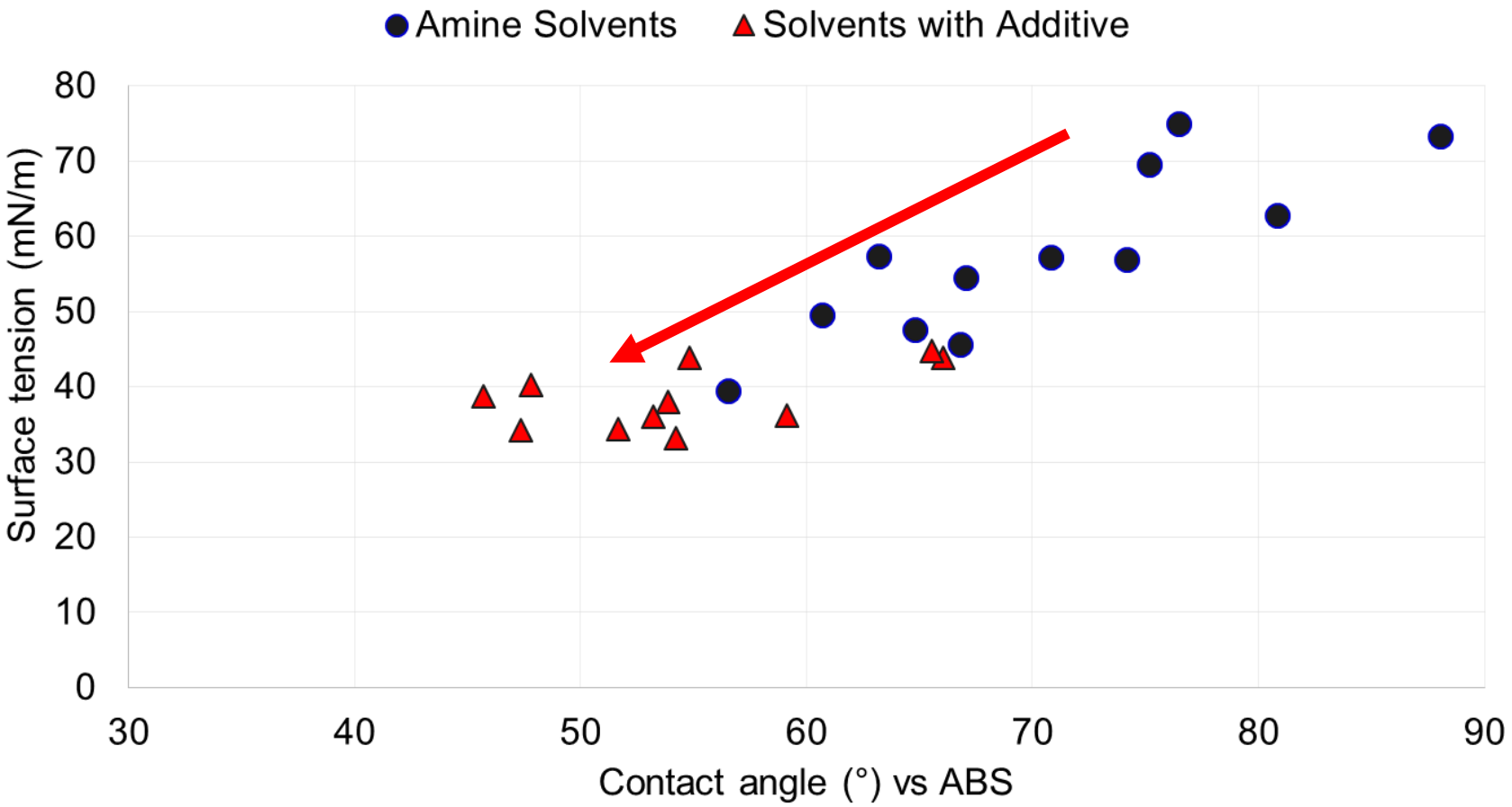
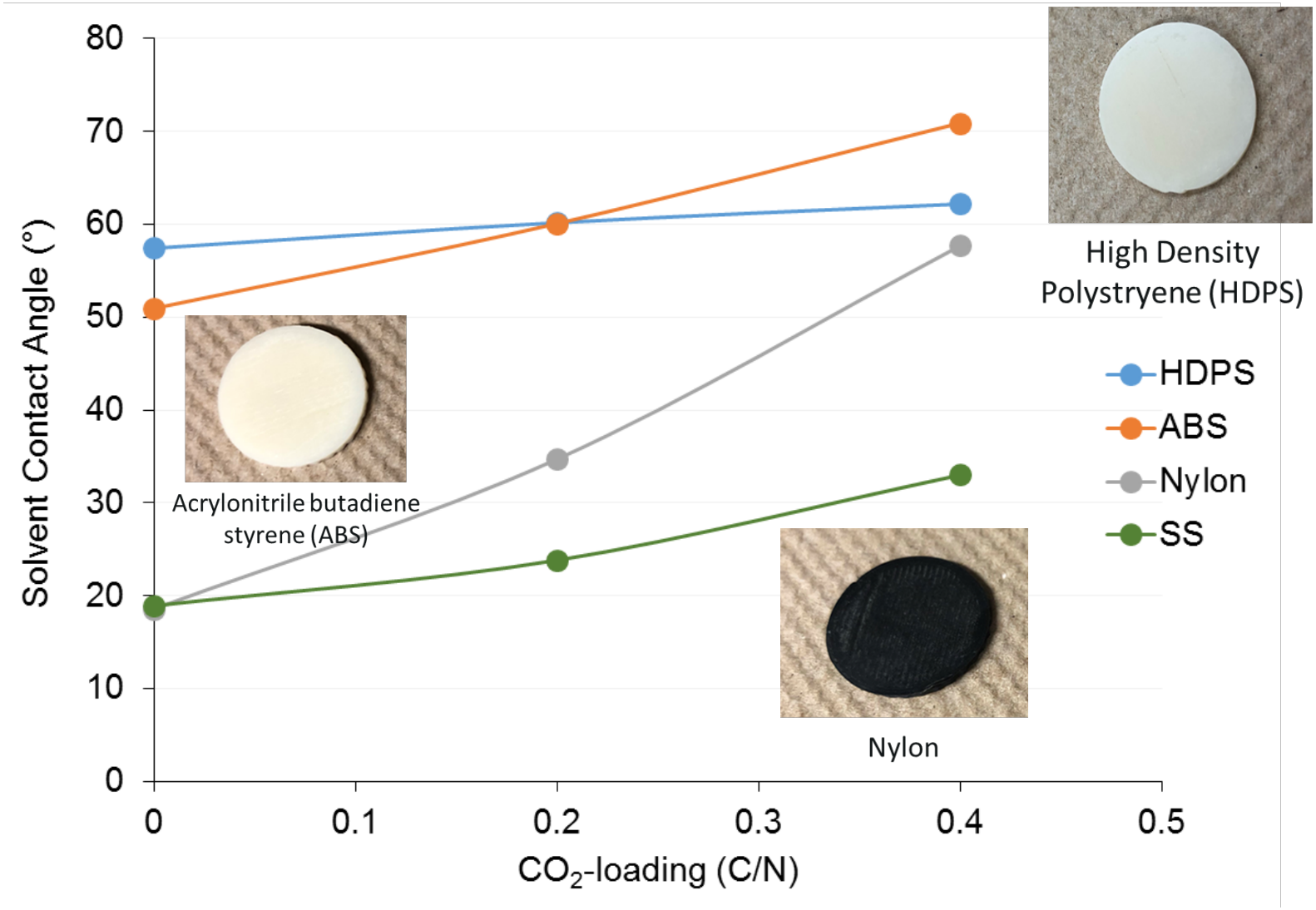


A very small amount of surfactant-type additive (< 0.1%) can be used to reduce the surface tension (ave. ↓30%) and contact angle (ave. ↓23%) of common amine solvents, helping to increase the wettability of these solvents on packing

Modify Physical Properties of Amine Solvents



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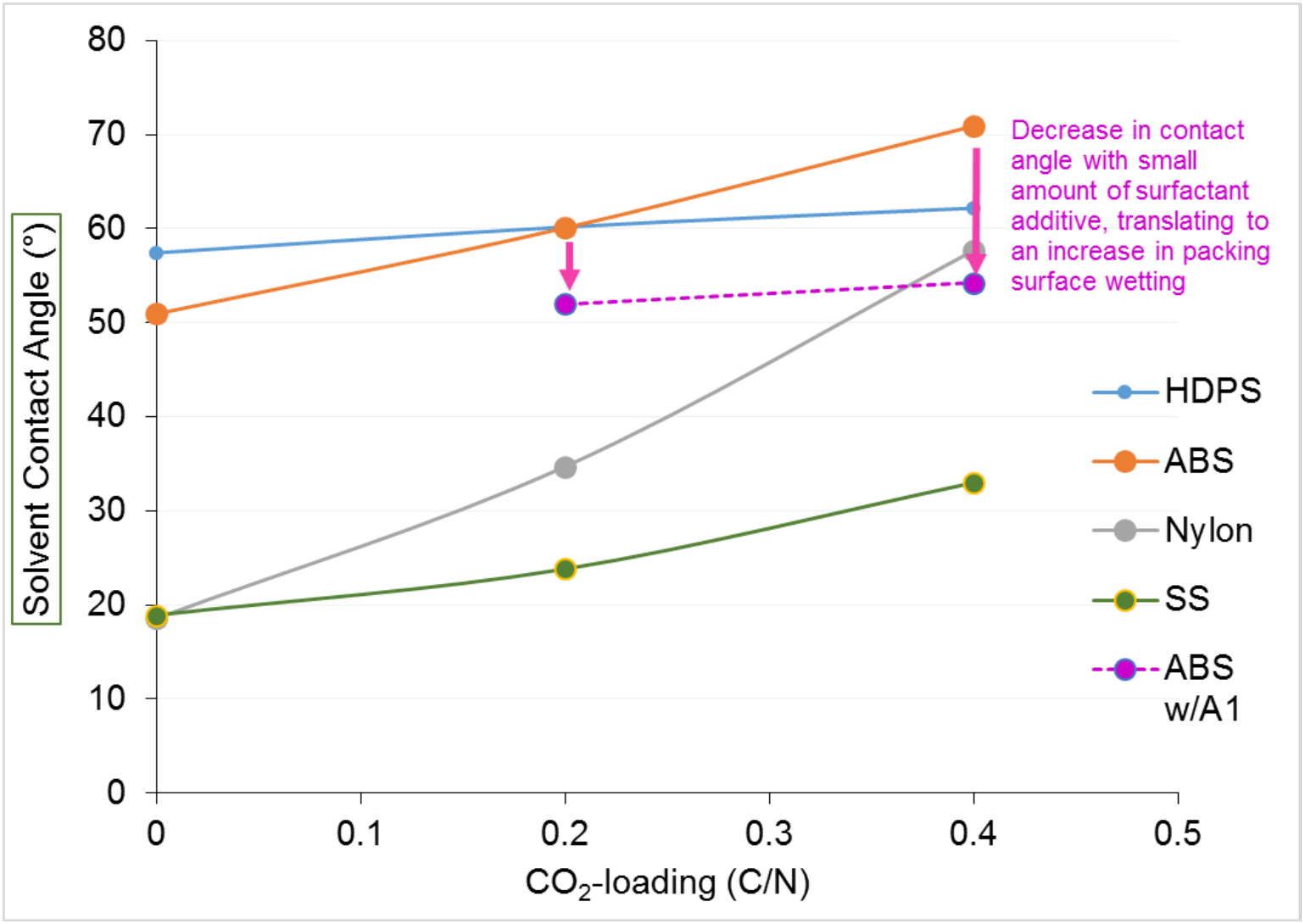
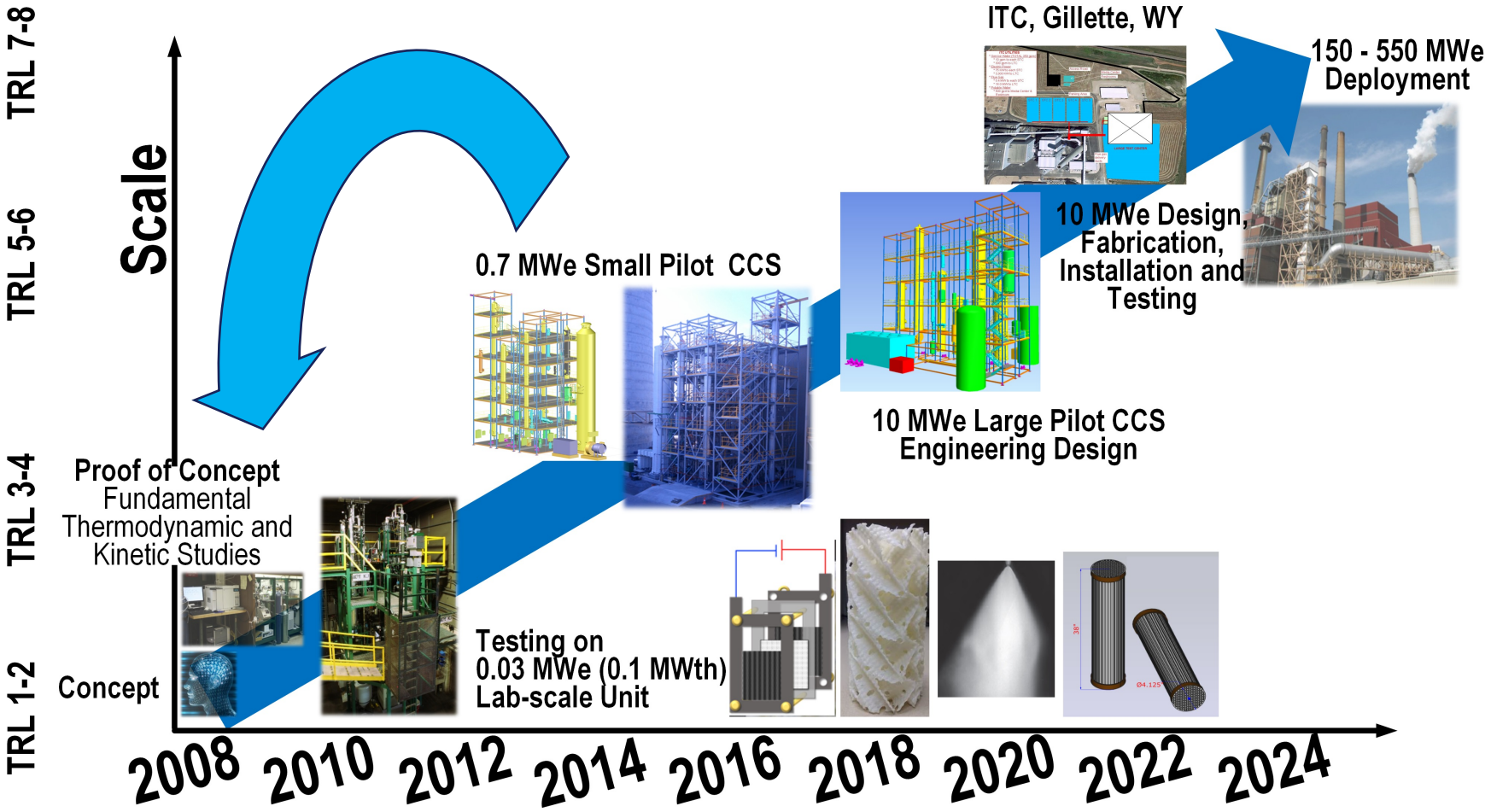


Key Knowledge Gained

- Understanding solvent physical properties is critical to increase CO_2 mass transfer and solvent wetting within the absorber
- Amine solvent physical properties can be modified through the addition of additives to decrease surface tension and contact angles (increase wettability) on polymeric packing surfaces

Technology Development Pathway



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