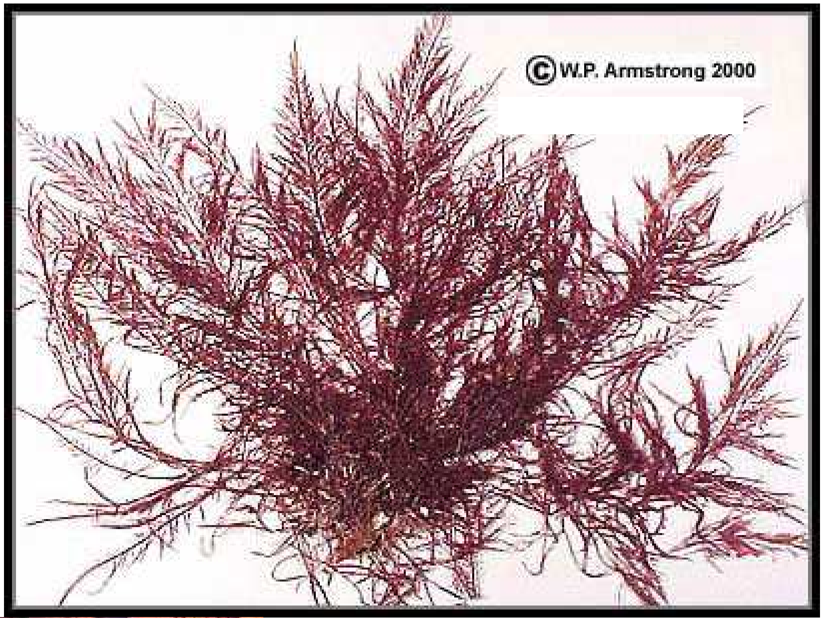
Drag Reduction Efficiency of Red Algal Extracellular Polysaccharides



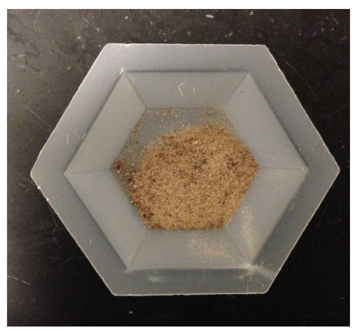
Yang He

Russell School of Chemical Engineering

Overview

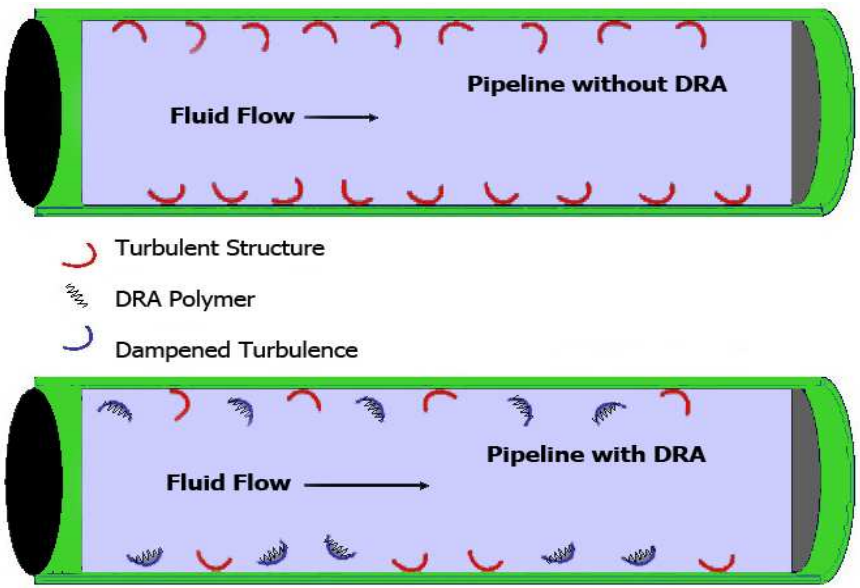
- Industrial drag reducing agent(DRA) and drag reduction efficiency test

- Red algal polysaccharides



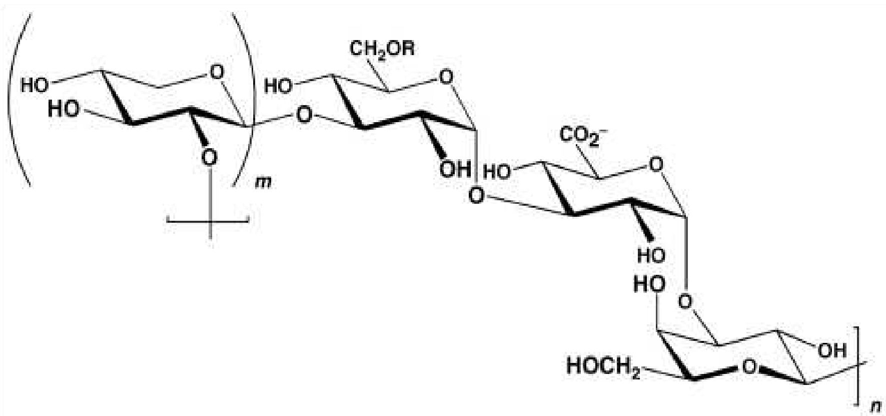
- R

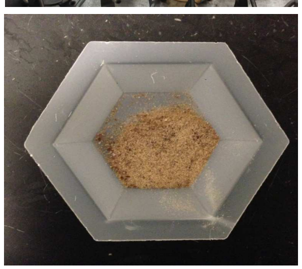
Drag Reducing Agents(DRA): Long chain polymer chemicals that when injected into a pipeline where the fluid is turbulent modifies the flow regime by reducing the frictional pressure drop along the pipeline length



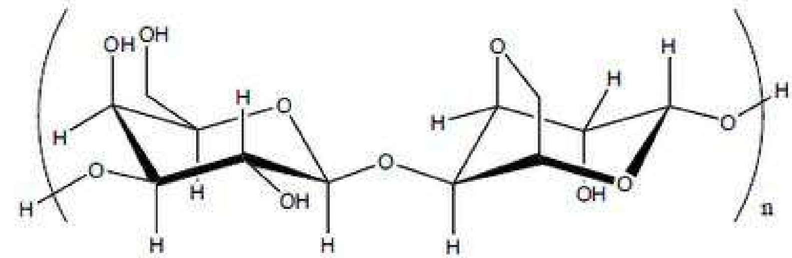
Algal polysaccharides used in this study

Red microalgae *Porphyridium sp.* polysaccharides *(P. cruentum and P. aerugineum)*



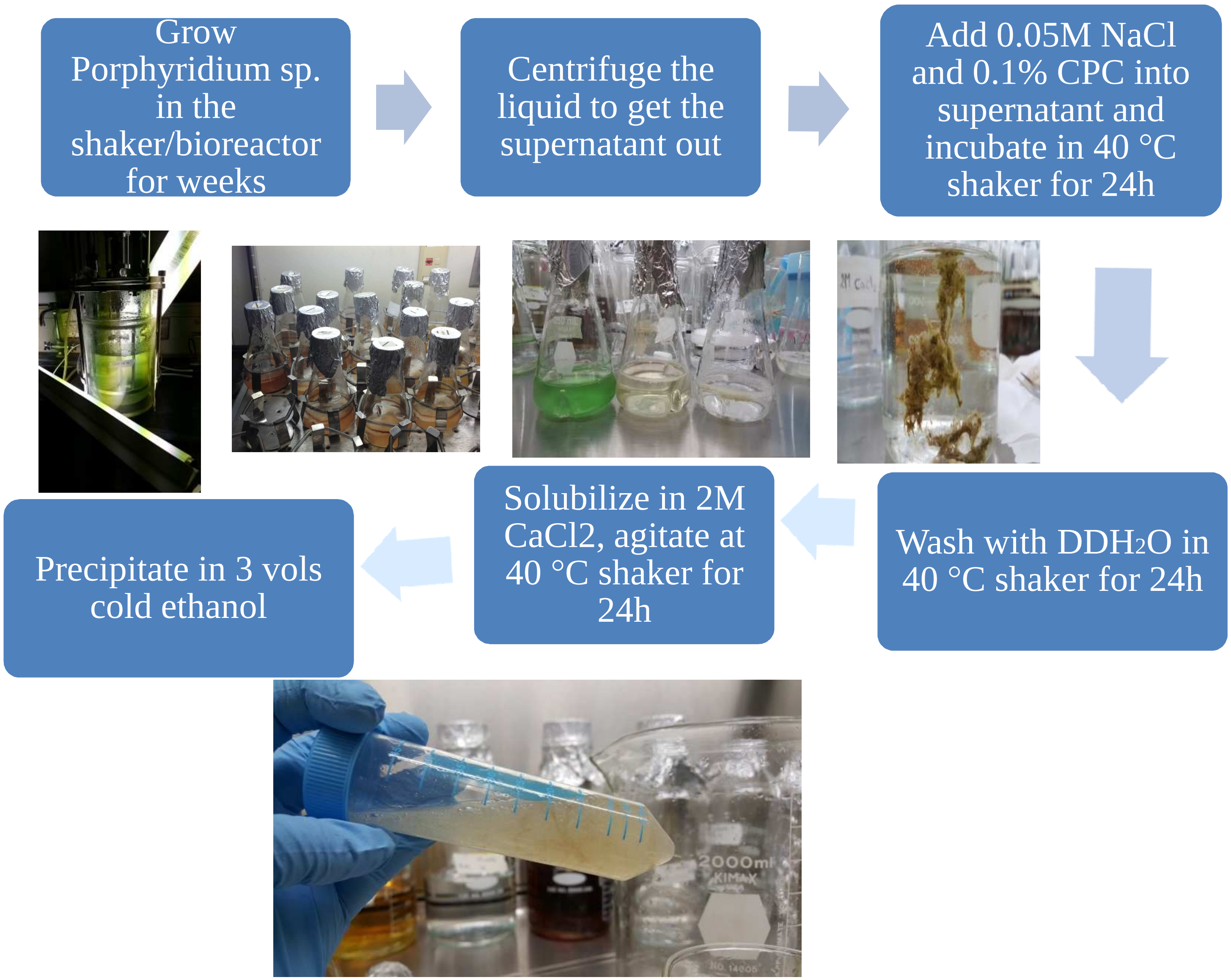


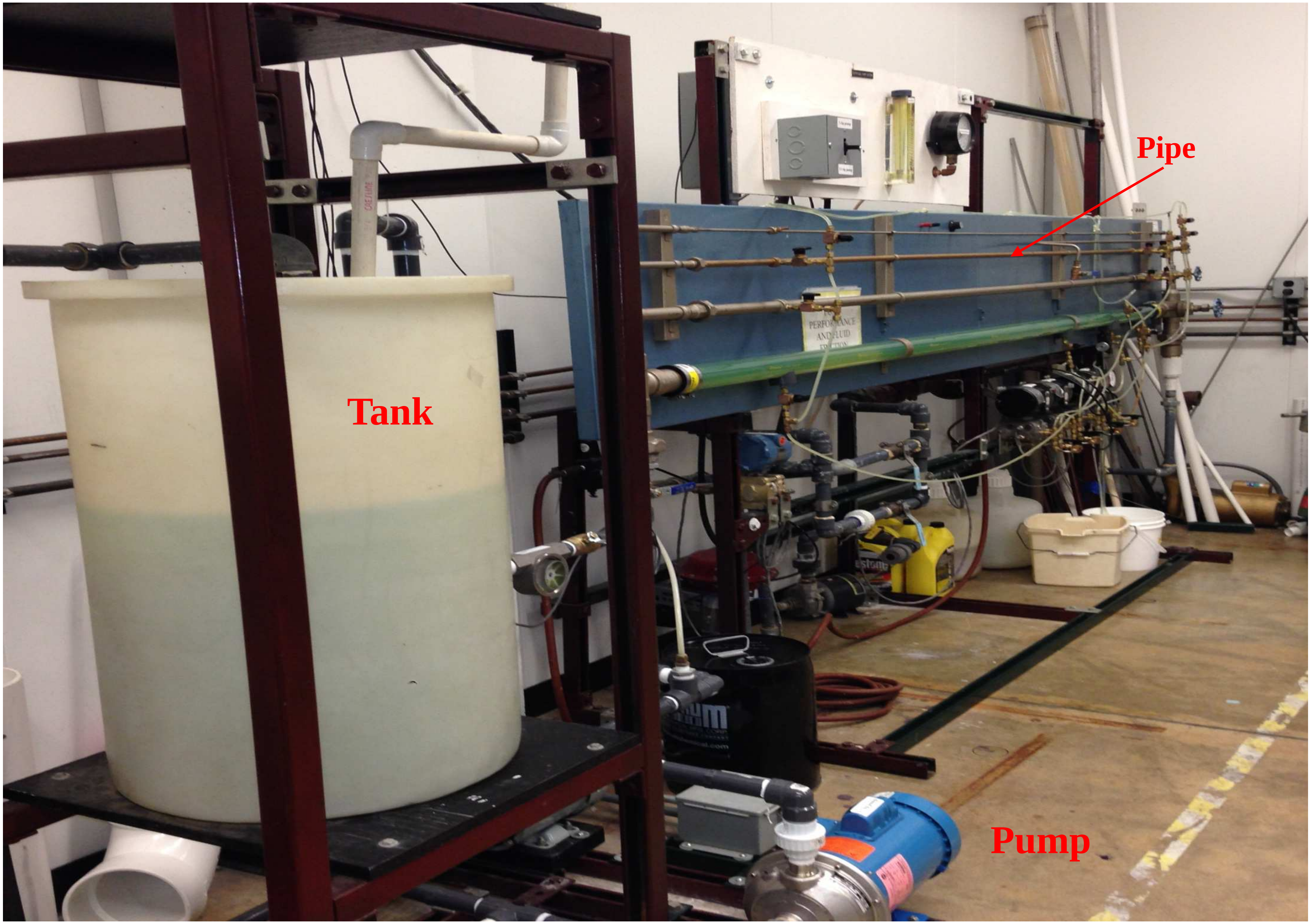
Red microalgae polysaccharide agarose *(Agar)*



Structure the agarose:
repetition of (1-> 3)-β-D-galactopyranose (left)
and of (1-> 4)-(3,6)-anhydro-α-L-galactopyranose (right).

Red microalgae *Porphyridium sp.* polysaccharides extraction procedure

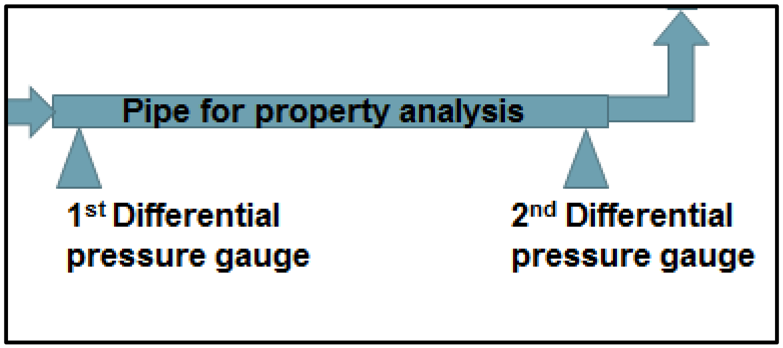



Pipe
Tank
Pump

Experimental settings

- Diameter: 1/2 in. copper
- Length: 8 ft
- Total volume: 40 L
- Pump capacity: 0.75 hp
- Concentration: tested by phenol-sulfuric acid carbohydrates assay
- Reynolds: 27000 (flow rate 4.67 gal / min)

Drag in a pipe system calculation



$P_{1,2}$ - pressure measured at points 1 and 2, psi
H_L - head loss, ft
f - friction factor, dimensionless
D - pipe diameter, ft
L - pipe length, ft
v - fluid velocity, ft/s

f_w - friction factor with additive
$f_{w/o}$ - friction factor without additive

Darcy-Weisbach equation

$$P_2 - P_1 = \Delta P$$

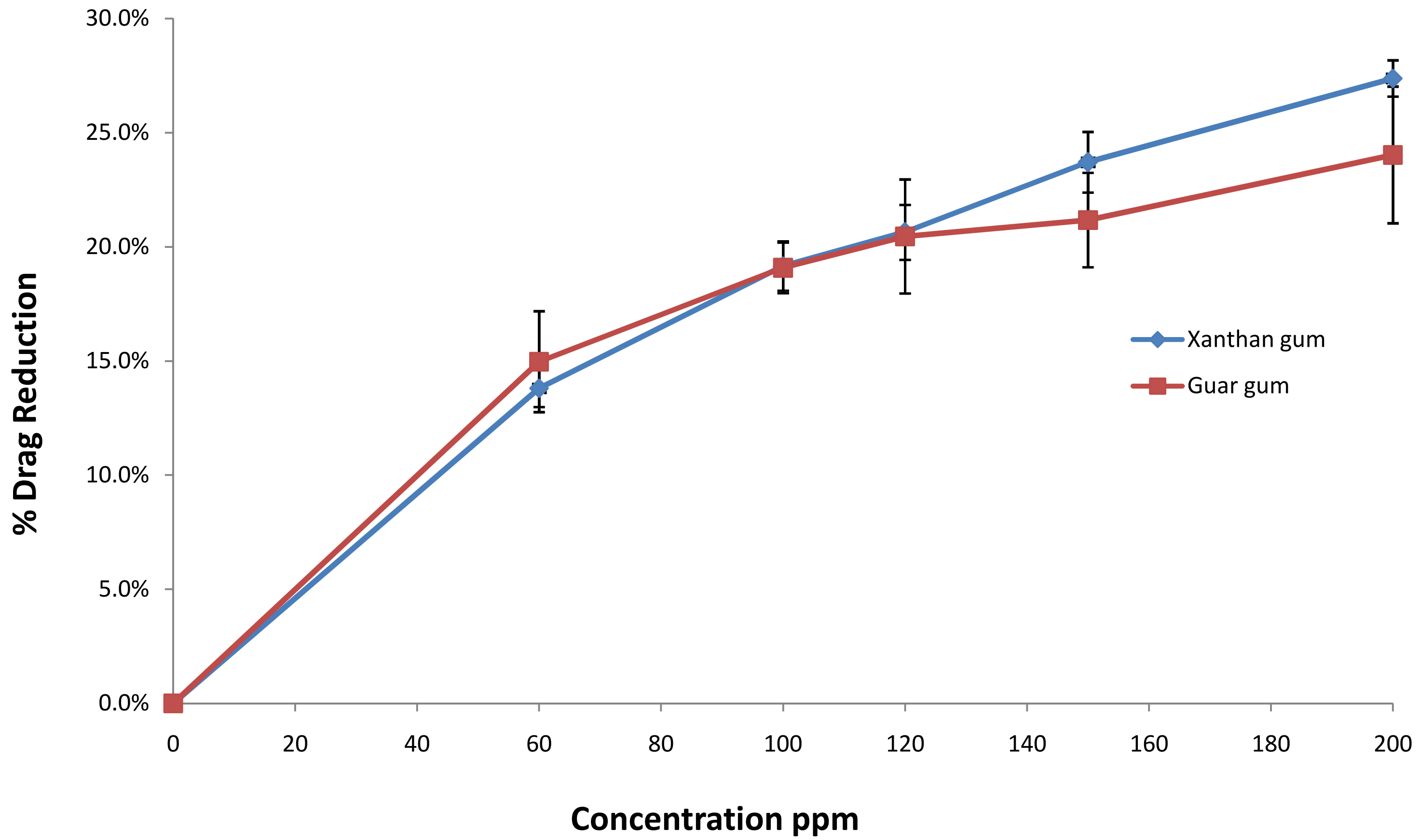
$$H_L = \frac{\Delta P}{\rho g}$$

$$f = H_L \left(\frac{D}{L}\right)\left(\frac{2g}{v^2}\right)$$

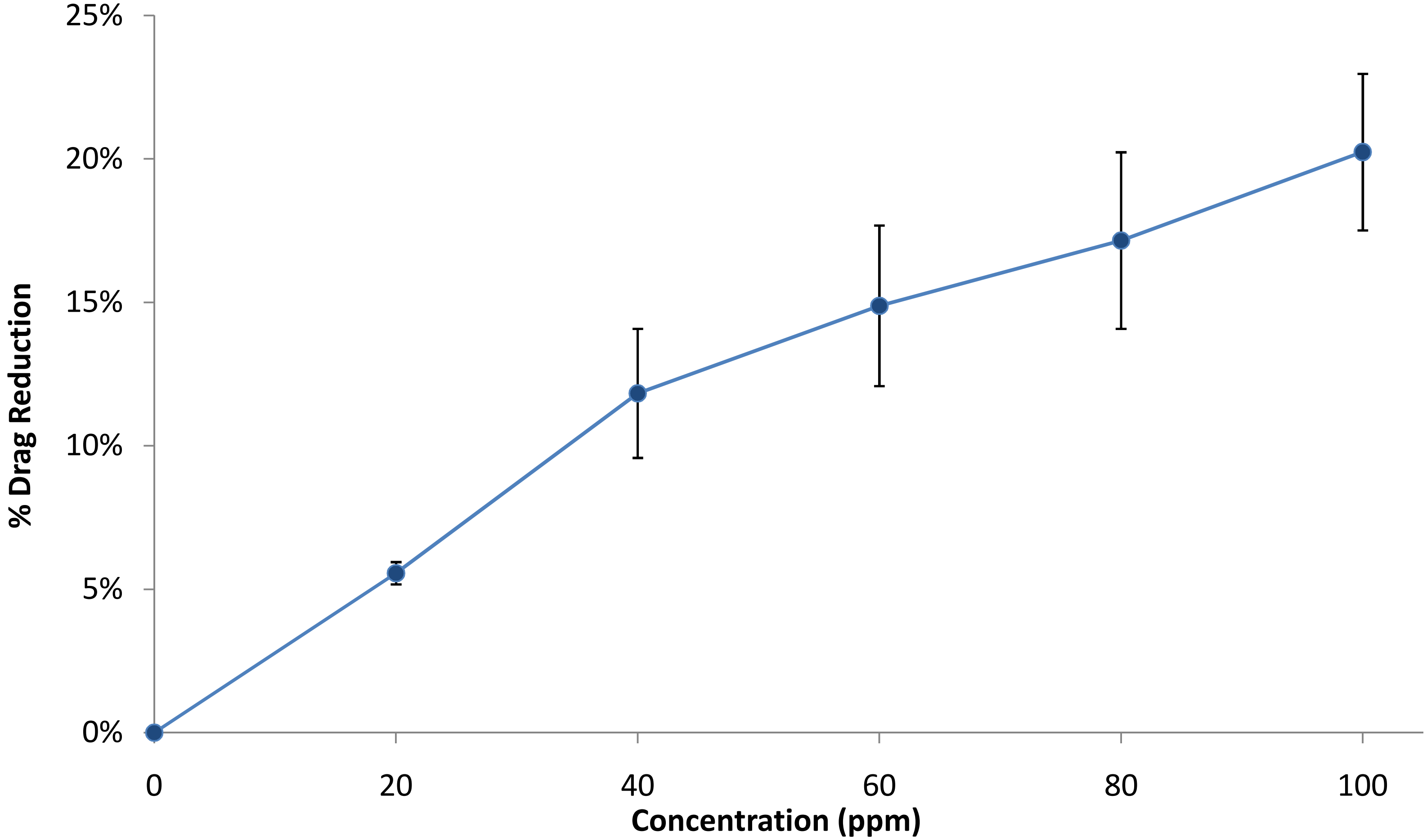
Generally definition of percentage drag reduction

$$DR(\%) = \left(1 - \frac{f_w}{f_{w/o}}\right) \times 100$$

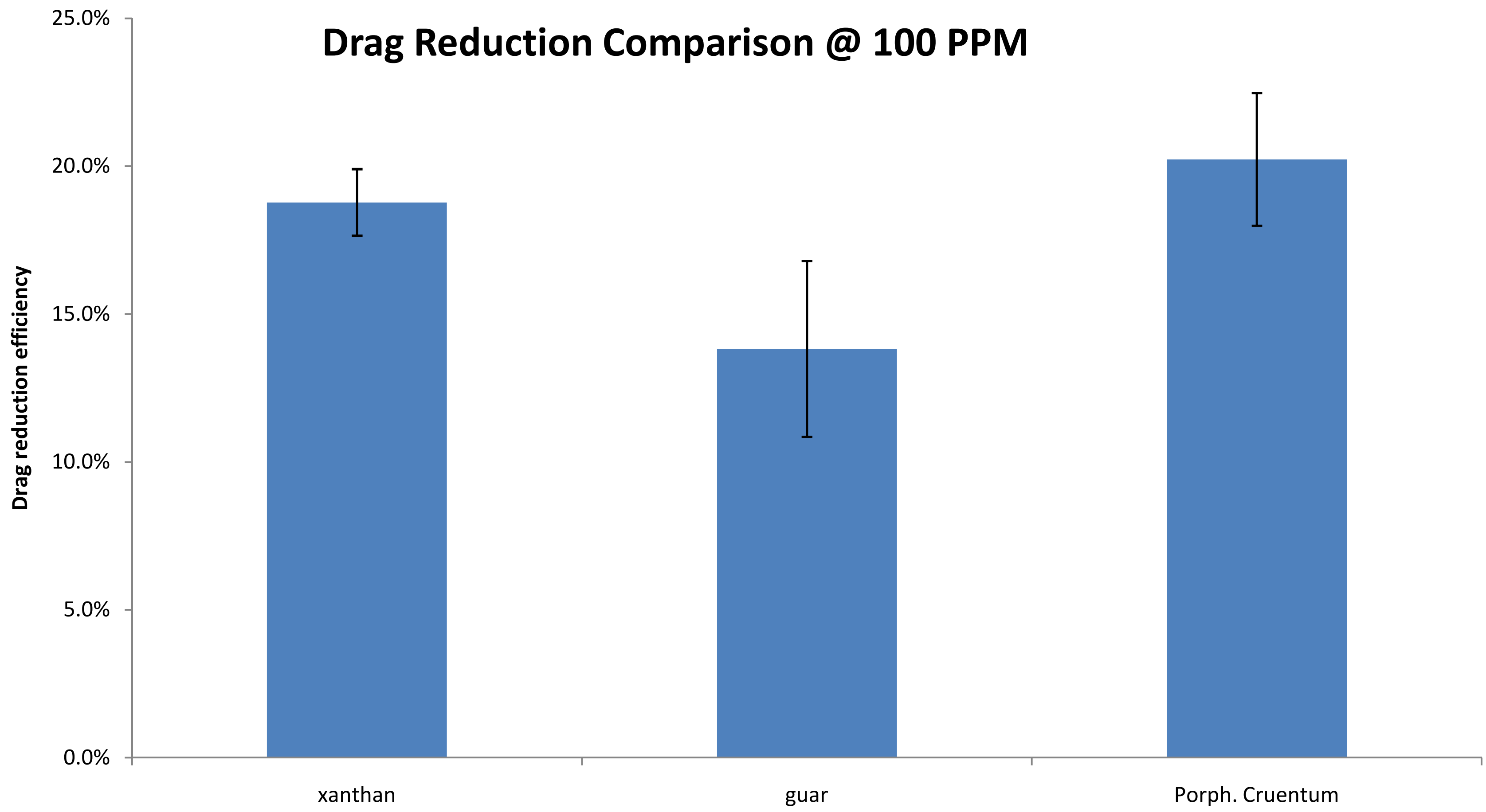
Effect of Polysaccharide Concentration for Industrial Used Gums



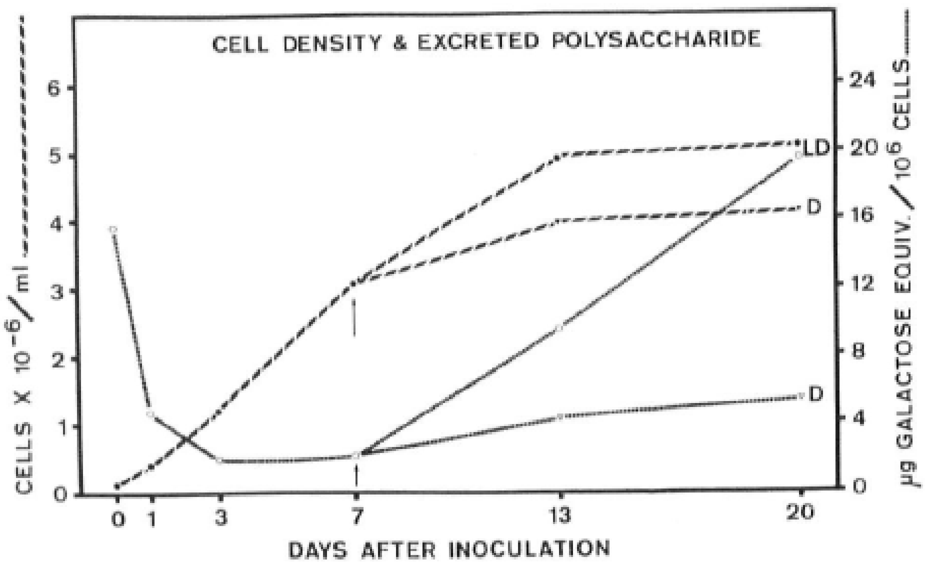
Effect of Polysaccharide Concentration for Red Microalgae *Porphyridium cruentum.*



Drag Efficiency Comparison of Red Algal Polysaccharides and industrial gums



Red Microalgae *Porphyridium aerugineum* Production & Drag Reduction Efficiency

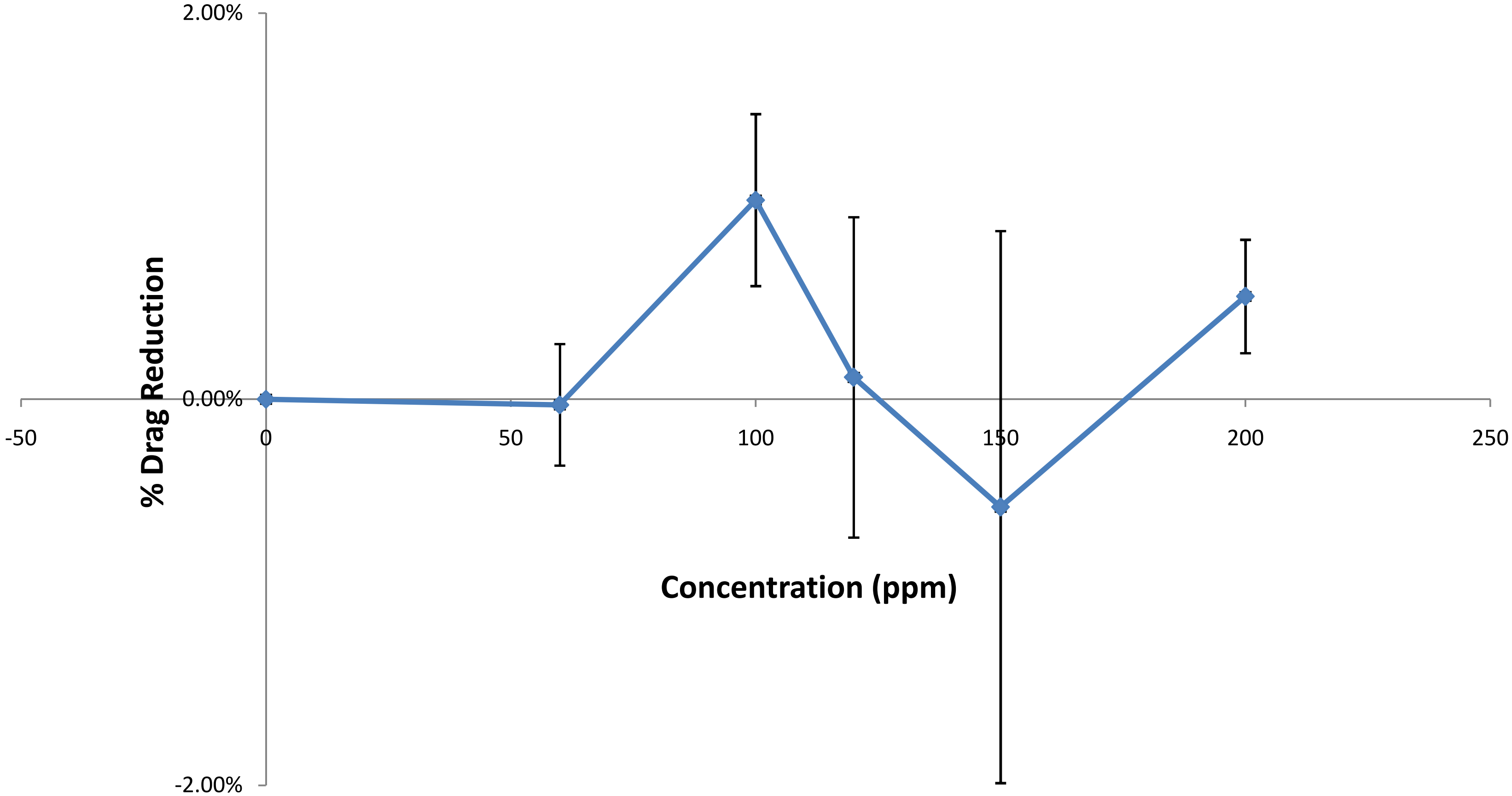


Porphyridium aerugineum ppm	Drag reduction efficiency
15	5.4%
15	6.5%
15	4.3%
15	5.6%
15	5%

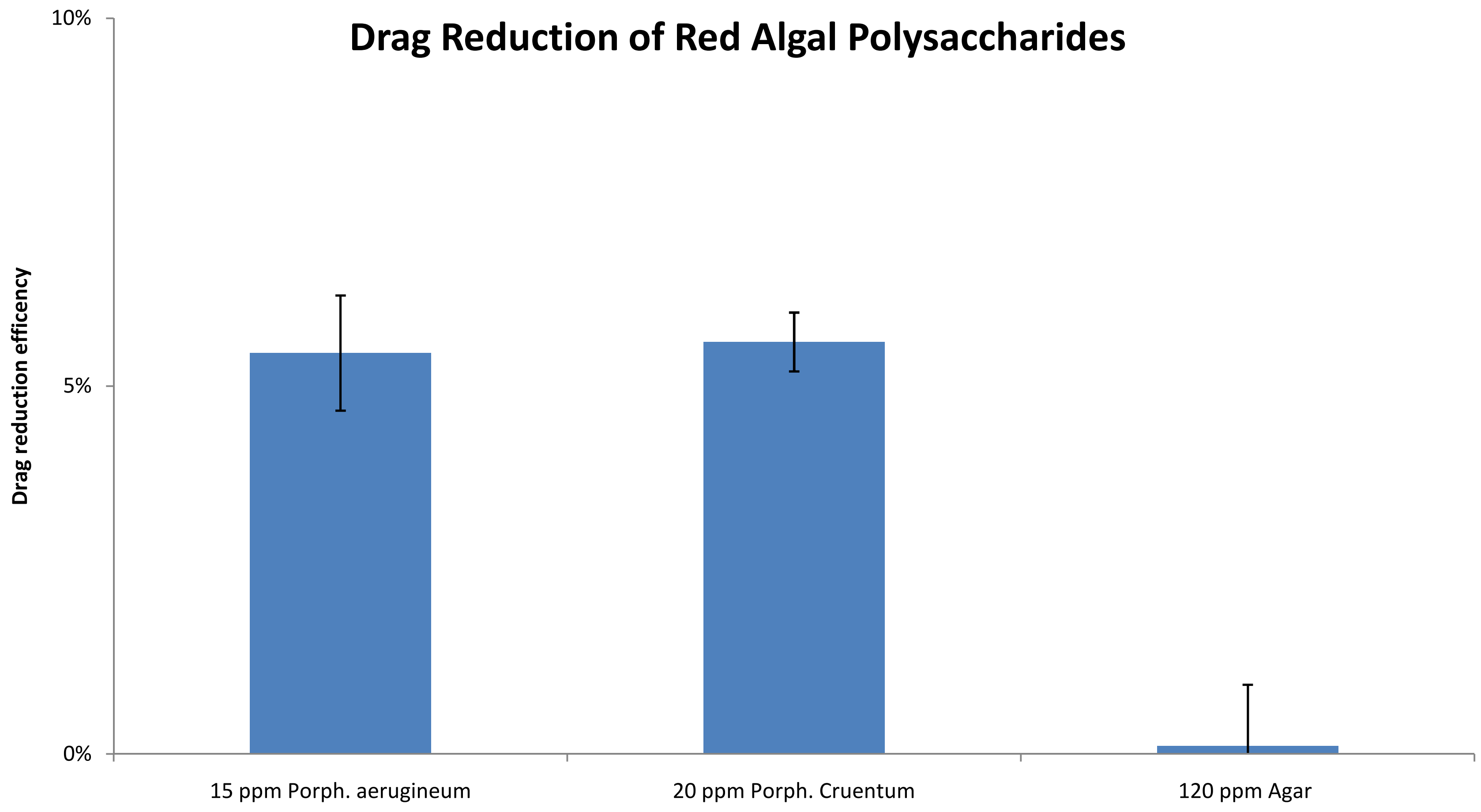
Production of polysaccharide in stationary phase is about 4mg/L

* J. Ramus. 1972. The production of extracellular polysaccharide by the unicellular red alga *porphyridium aerugineum*. *J. Phycol*. 8, 97-111

Effect of Polysaccharide Concentration for Agar

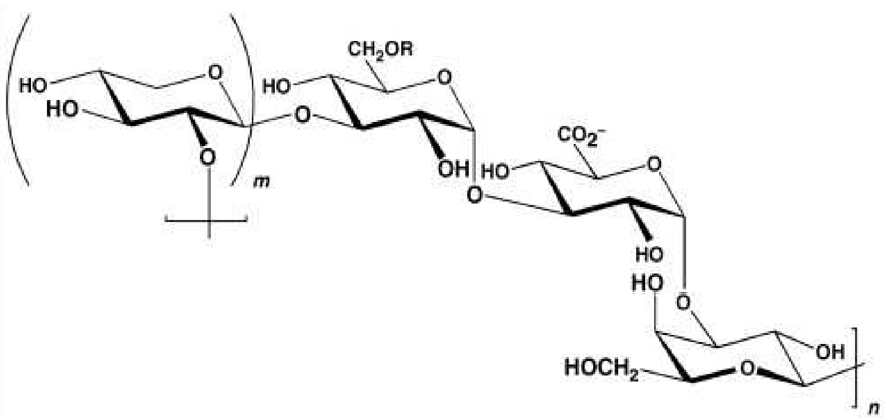


Drag Efficiency Comparison of Red Algal Polysaccharide

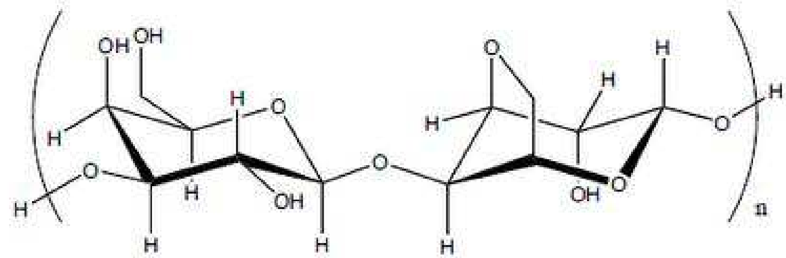


Chemical Structure of different polysaccharides

Red microalgae *Porphyridium sp.* polysaccharides
(P. cruentum and P. aerugineum)

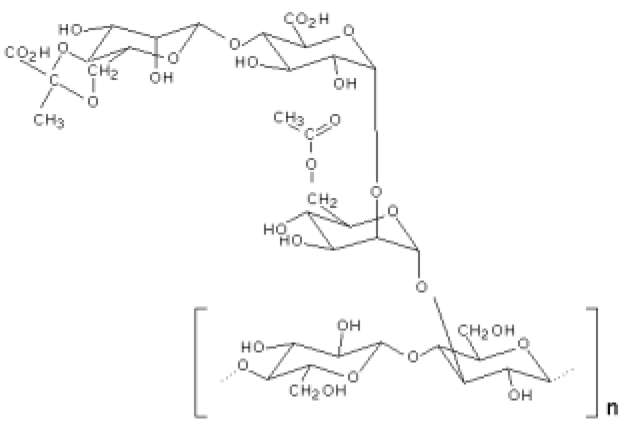


Red microalgae polysaccharide agarose *(Agar)*

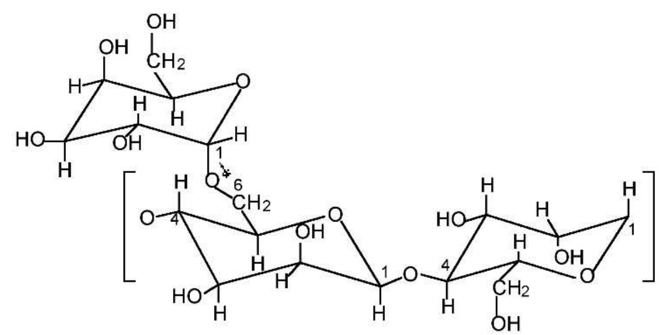


Structure the agarose:
repetition of (1-> 3)-β-D-galactopyranose (left)
and of (1-> 4)-(3,6)-anhydro-α-L-galactopyranose (right).

Xanthan gum



Guar gum



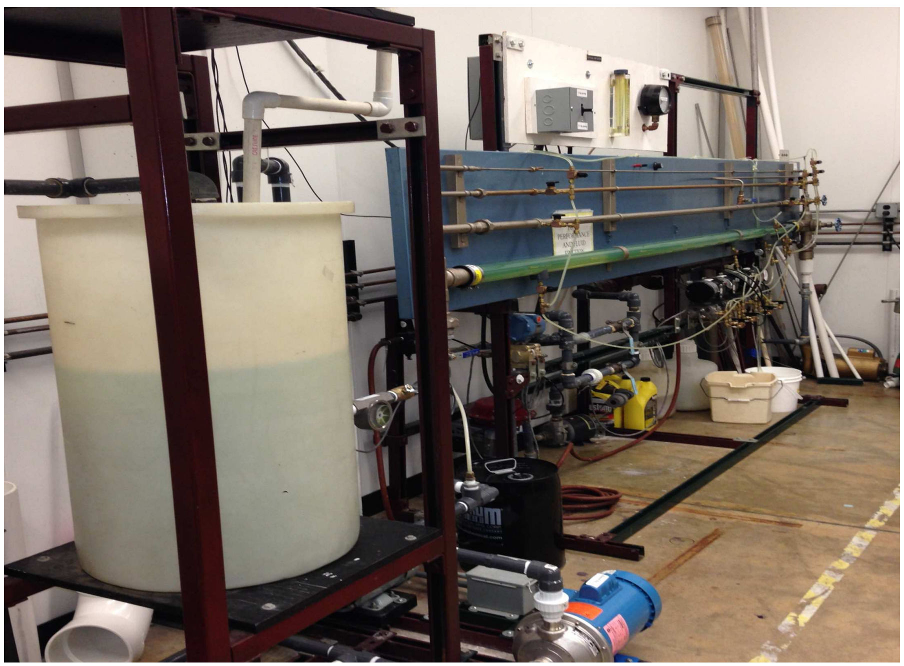
Conclusion

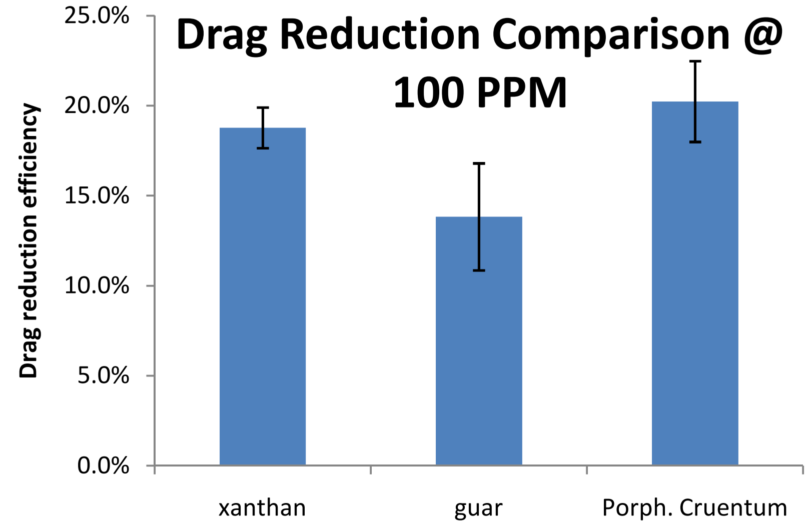
- Production of *Prophyridium sp.* Polysaccharides is limited

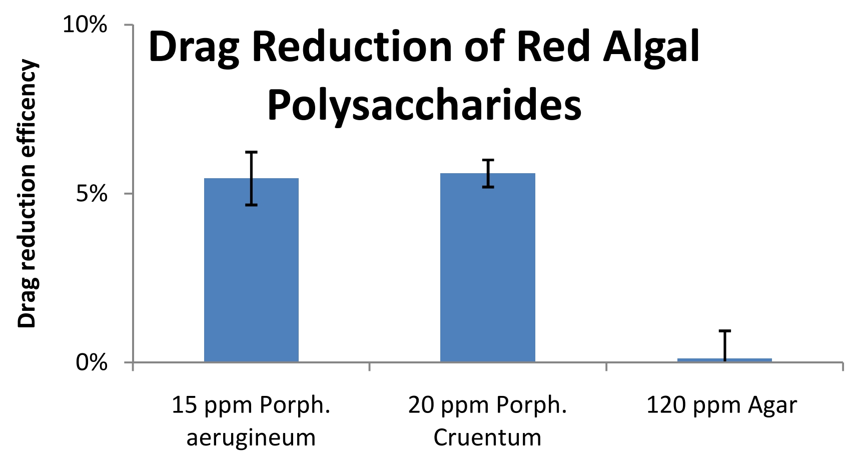
- Red microalgae *Prophyridium sp.* polysaccharides have the potential to be used as DRAs but not all of the algal extracellular polysaccharides works

Summary


2000ml
KIMAX




Drag Reduction Comparison @ 100 PPM
Drag reduction efficiency
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
xanthan
guar
Porph. Cruentum


Drag Reduction of Red Algal Polysaccharides
Drag reduction efficency
10%
5%
0%
15 ppm Porph. aerugineum
20 ppm Porph. Cruentum
120 ppm Agar