MASS TRANSFER RATE OF NON-SPHERICAL PARTICLES IN TURBULENCE USING SUGAR-GLASS RECIPE

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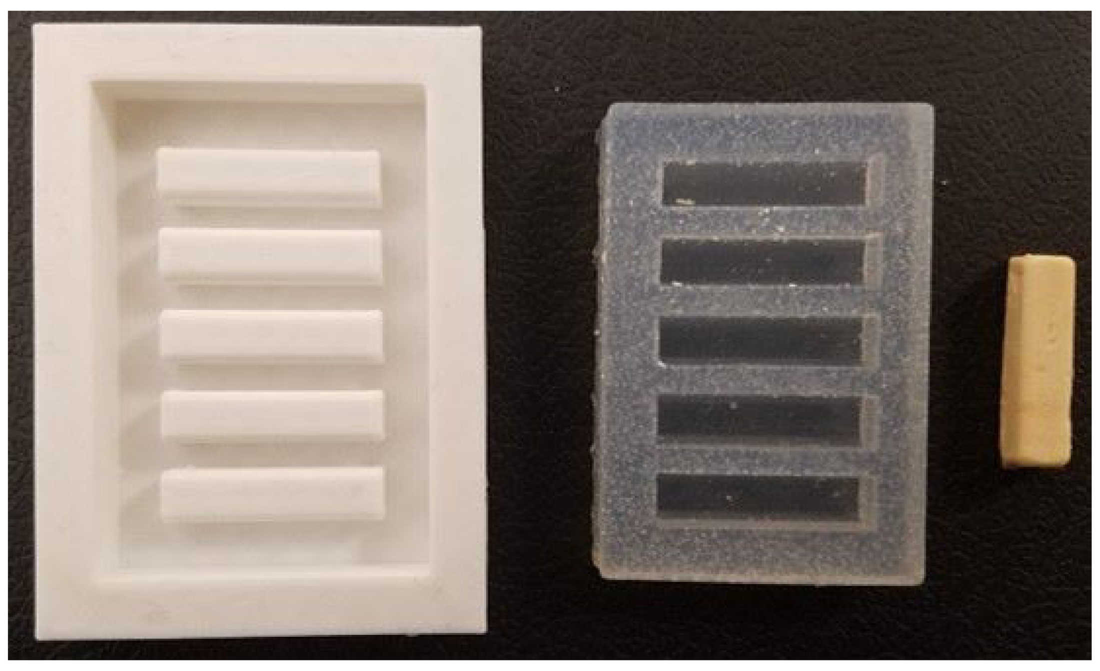
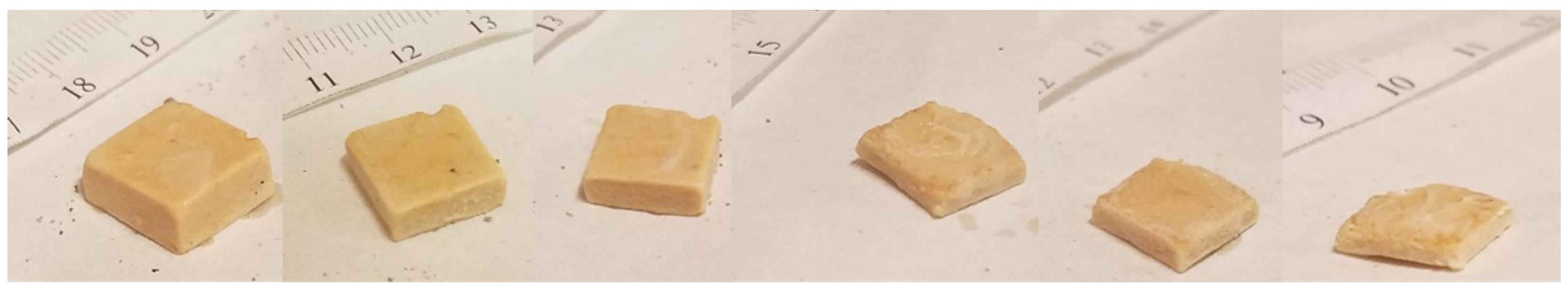
Abstract

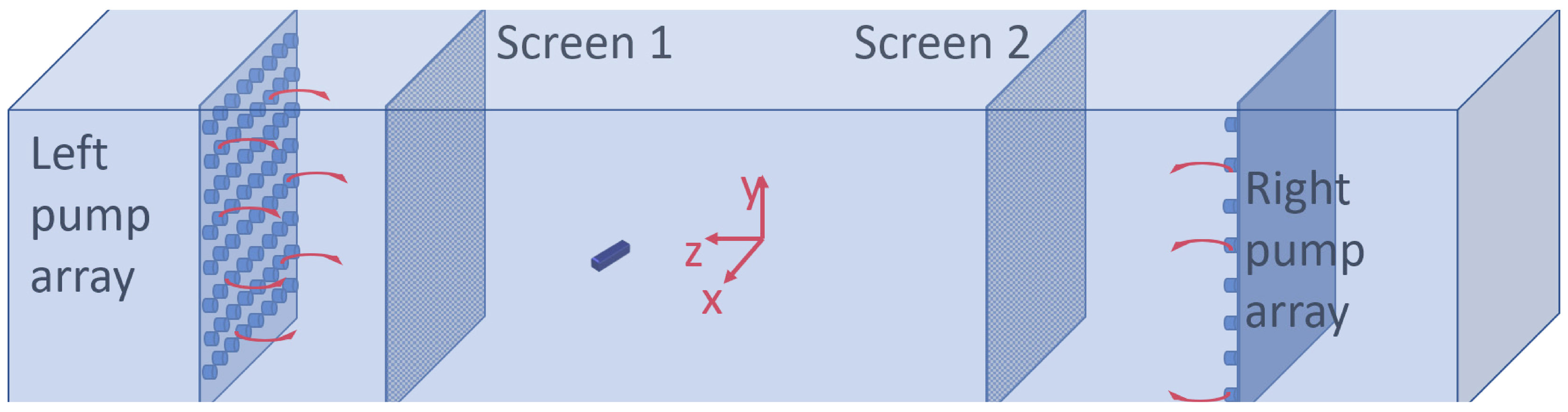
We evaluate the mass transfer rate from the surface of rod- and disc- shaped particles. The method of particle fabrication used here builds off of both traditional gypsum plaster dissolution methods and advances in sugar-glass particle recipes. We hypothesized that the turbulent flow would affect the boundary layer surrounding these particles and therefore their mass transfer rate. Results from these experiments show the dependence of shape and surface area on mass transfer rate in turbulent flow. The related questions are relevant to cases of marine biology, carbon sequestration, and pollution by plastics.

Methods





increasing time →



Custom manufactured sugar-glass particles are tested in homogeneous, isotropic turbulence.

Hixson-Crowell Law

Cube Parameters

$$\frac{d\forall}{dt} = 3r^2\frac{dr}{dt}$$

Noyes-Whitney

$$-\frac{dM}{dt} = \frac{D}{\delta}AC_s$$

Equating Changes in Mass and Volume:

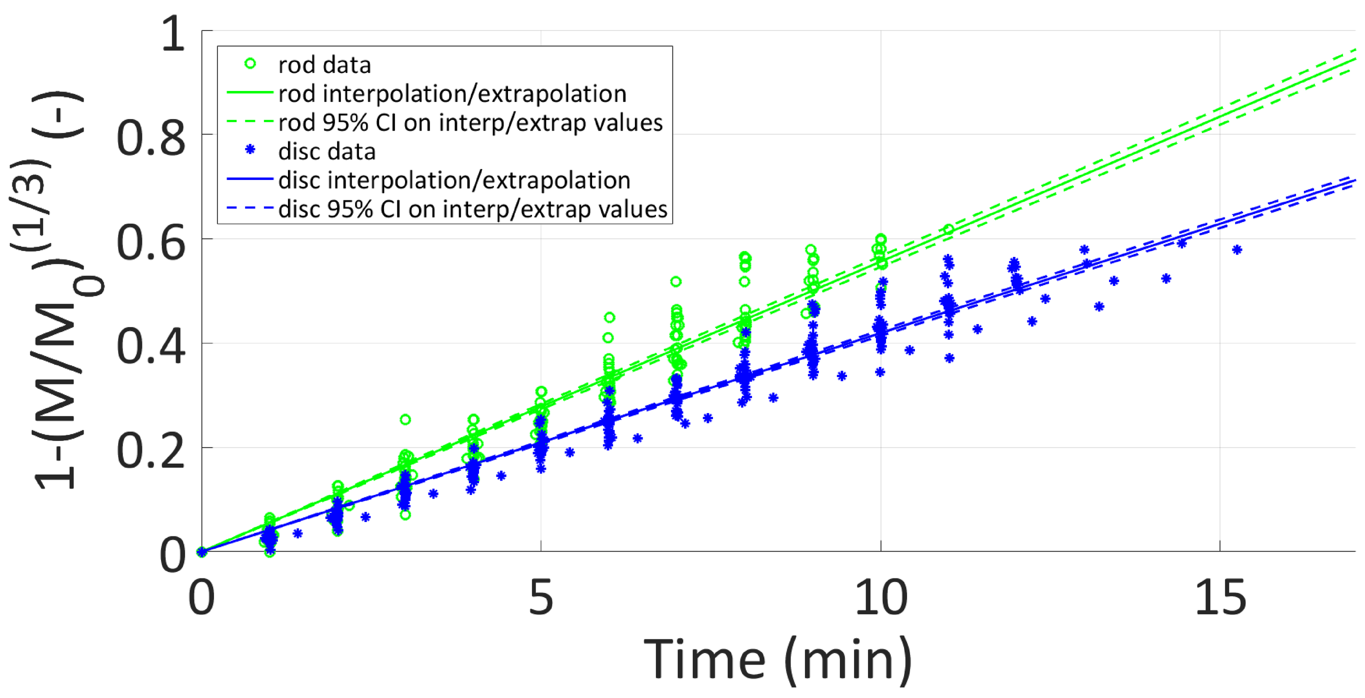
$$\rho\frac{d\forall}{dt} = \frac{dM}{dt} \Rightarrow \rho\, 3r^2\frac{dr}{dt} = -\frac{D}{\delta}AC_s$$

integrating, substituting $r = (M/\rho)^{1/3}$

and rearranging $$1 - \sqrt[3]{M_t/M_0} = k_0 t$$

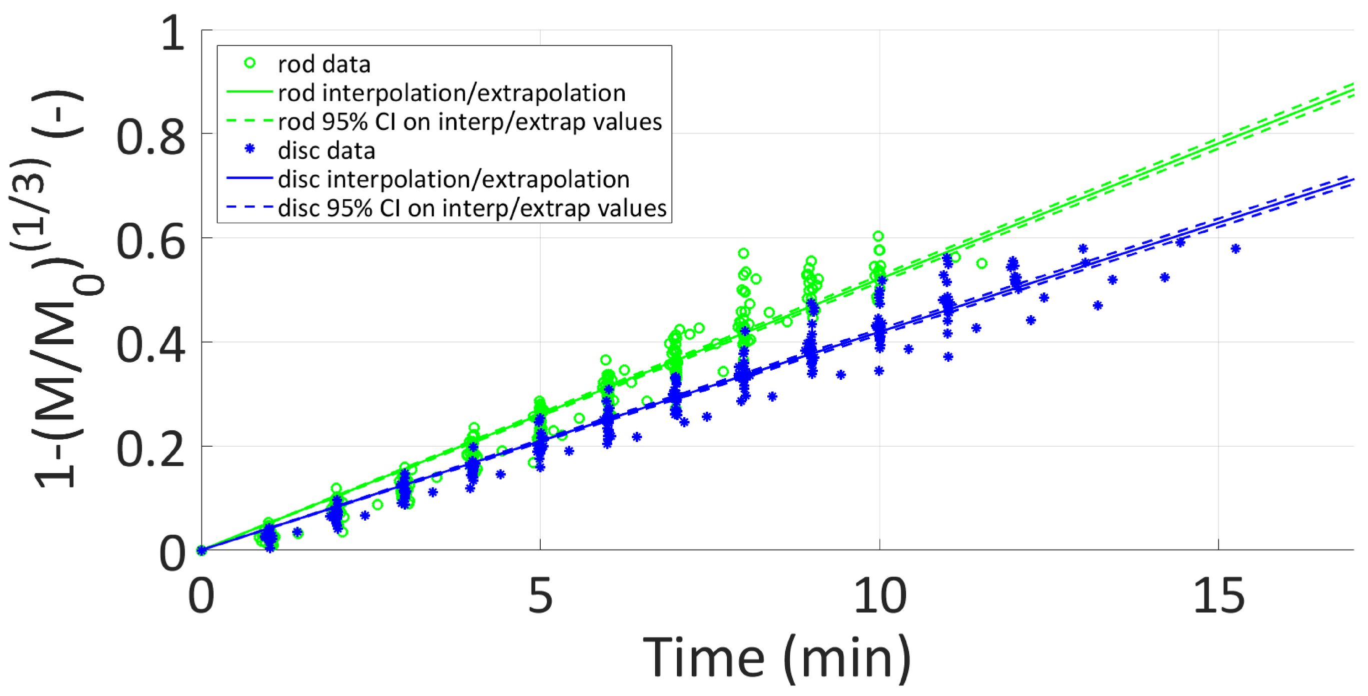
Results and Discussion

Volume Matched Particles



Particle type	Effective dissolution rate, k_0 [1/min]	Confidence interval [1/min]	R-squared value
Rod	5.56×10^{-2}	[5.46×10^{-2} 5.67×10^{-2}]	0.95
Disc	4.19×10^{-2}	[4.14×10^{-2} 4.25×10^{-2}]	0.97

Surface Area Matched Particles



Particle type	Effective dissolution rate, k_0 [1/min]	Confidence interval [1/min]	R-squared value
Rod	5.21×10^{-2}	[5.14×10^{-2} 5.27×10^{-2}]	0.96
Disc	4.19×10^{-2}	[4.14×10^{-2} 4.25×10^{-2}]	0.97

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