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# Gas to liquid mass transfer in rheologically complex fluids

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## Abstract

The increase of studies relaying on gas to liquid mass transfer in digested sludge (shear thinning fluid) necessitates a better understanding of the impact of apparent viscosity ($\mu_a$) and rheology in process performance. Mass transfer retardation due to $\mu_a$ variations was investigated in a pilot scale absorption bubble column for Newtonian and shear thinning fluids with varied superficial gas velocities ($U_G$). A non-linear reduction of mass transfer efficiency with increasing $\mu_a$ was observed, being the impact higher at low $\mu_a$ ranges and high $U_G$. An increase of 114 cPo in μ from 1.01 to 115 cPo in glycerol solutions saturated with $U_G$ = 1.73 cm·s$^{-1}$ led to a reduction of 96% in $k_La$ (α = 0.04), while a comparable raise from 115 to 229 cPo implied a reduction of 52% (α = 0.02).

Slug-annular flow regime was identified for shear thinning fluids of high $\mu_a$ (1.0 and 1.5% carboxymethyl cellulose sodium salt solutions), where bubble buoyancy was conditioned by the μ of the fluid at rest and the active volume for mass transfer was reduced because of the presence of



*AD: anaerobic digester; C: concentration in the liquid phase; $C^*$: solubility as equilibrium $CO_2$ concentration at infinite time; $C_0$: concentration at time cero; $C_t$: concentration at time t; $C_{model}$: concentration estimated with Eq. 5; $C_{sensor}$: concentration measured by the probe; CMC: carboxymethyl cellulose sodium salt; $\dot{F}_{CO_2}$: incoming $CO_2$ mass flow rate; GTE: gas transfer efficiency; GTR: gas transfer rate; K: consistency index; $k_La$: volumetric mass transfer coefficient; $(k_La)_T$: volumetric mass transfer coefficient at temperature T; $(k_La)_{20}$: volumetric mass transfer coefficient at 20°C; $(k_La)_{UG}$: volumetric mass transfer coefficient obtained with $U_G$, $(k_La)_\mu$: volumetric mass transfer coefficient obtained with a liquid phase with μ; m: Cross rate constant; Re: Reynolds number; $U_G$: superficial gas velocity; $t_f$: characteristic time of the mass transfer; $U_{trans}$: transition superficial gas velocity between bubbly and churn-turbulent flow regimes; V: volume of liquid inside of the bubble column; ζ: probe's response time; μ: dynamic viscosity; $\mu_a$: dynamic apparent viscosity; $(\mu_a)_{av}$: average dynamic apparent viscosity; $\mu_0$: zero shear viscosity; $\dot{\Upsilon}$ : shear rate; $\dot{\Upsilon}_{av}$ : average shear rate.*