

Background and Objective

The Minamata convention on mercury (Hg) was enforced at United Nation in 2017 to reduce the mercury concentration in the natural environment. For its effective implementation, more accurate understanding of the mercury cycle is important. Here we report the preliminary results of laboratory experiments for the uptake of gaseous elemental mercury (GEM) by acidified water, representing atmospheric fog, cloud, and rain, the information of which is very limited.

Method

In a 2.5 L vessel under 25 ° C and the atmospheric pressure, 500 mL of water acidified with HCl, HNO₃, or H₂SO₄ (Nakarai Tesque, Japan) was exposed to the continuously flown GEM standard gas in *ca.* 60 ng m⁻³ generated by a permeator (Dynacalibrator-345, VICI, Fig. 1). After the exposure for a specific duration, the gas flow was ceased and the solution was quickly stirred and siphoned out into a clean container. 450 mL of the exposed sample was mixed with 50 mL of 36% HCl to stabilize Hg ions. Hg ions in the sample was reduced to GEM by 3% SnCl₂ in 10% HCl, and GEM was captured by the gold-amalgam method and then analyzed by a flash vaporizer coupled with cold-vapor atomic absorption spectrometry.

Results and Discussion

During the experiment a small amount of Hg was detected from the water exposed to the GEM gas for more than a day (0.01 ng or less in 500 mL water). Results exhibited that the uptake of GEM by the acidified solution was very weak (Table 1) even to the water with high acidity (pH = 3.2), which may be found in fog water in the polluted area. The masses found in water were not comparable to the estimated solubility of GEM, 0.09 ng per 500 mL of water according to the Henry's law with the dimensionless constant of 0.32 at 298K,¹ but the masses found in the acidified solutions by either HNO₃ or H₂SO₄ were compatible with this value. Using the data of temperature and GEM concentration measurements, the reactive uptake coefficients (γ_{rxn} , defined by the eq. below), were determined. The estimated γ_{rxn} were between 7 and 22 × 10⁻⁶, very small as compared to the γ_{rxn} of ozone, glyoxal, N₂O₅ by the PM surface.²⁻⁴ Given the size and number concentration of fog droplets as 10 μm and 10² cm⁻³, respectively,^{4,5} the lifetime of GEM was calculated as 5 days. Comparing to a year of the atmospheric GEM life time, which is predominantly due to the oxidation by OH radicals, the heterogeneous uptake of GEM by atmospheric water can be an important process. Further careful evaluation, such as on the discrepancy between the result of this experiment and the solubility to water estimated by the literature values, is needed.

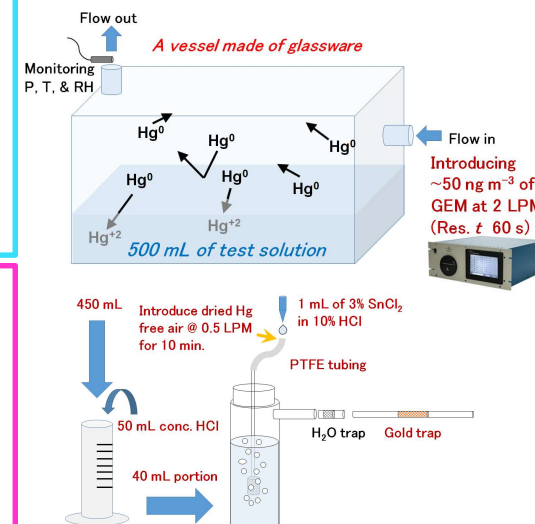


Fig. 1. Scheme of Uptake Experiment.

Table 1. Summary of Uptake Experiment.

	pH	Exposure time (h)	GEM conc. (ng m ⁻³)	Total Hg in the solution (ng)	γ_{rxn}
Sample 1	3.21 (HNO ₃)	2.4	55 ng / m ³	0.071	6.7 × 10 ⁻⁶
Sample 2	3.24 (H ₂ SO ₄)	6	60 ng / m ³	0.094	22.2 × 10 ⁻⁶

$$\gamma_{\text{rxn}} = \frac{\text{Number of Hg ions found in the solution}}{\text{Number of GEM atoms collided to the surface}}$$

References: ¹Andersson et al. (Chemosphere, 2008); ²Liggio et al. (JGR Atmos, 2005); ³Smith et al. (JPC-A, 2002); ⁴Brown et al. (JGR Atmos., 2009); ⁵Podzimek, J. (Stud. Geophysica et Geod., 1997); ⁶Eliezer et al. (AE, 1993).