

Corrosivity of Hypobromous Acid Solutions from DBDMH and Activated HB2 Towards 304 and 316L Stainless Steel and Concrete

Experimental Methods

An experiment was designed to simulate in-use conditions whereby a HOBr solution (200 ppm as Br₂) from both activated HB2 and DBDMH was contacted with 304 stainless steel, 316L stainless steel and concrete samples for a 30-day period.

Corrosion of the stainless steel samples would release ferrous ions into the contacting solution. Transition metal ions are known to accelerate the degradation the HOBr. Also any halogen reactive organic material in the concrete would also deplete the HOBr concentration. Therefore, the 200 ppm as Br₂ solutions from activated HB2 and DBDMH were replaced when the concentration had fallen below 170 ppm as Br₂. Generally for both sources of HOBr the solutions in contact with the respective materials were replaced every other day.

The metal coupons were weighed before and after a 30-day contact period, and the weight loss was used to calculate the corrosion rate. The concrete samples were observed before and after the 30-day contact period for signs of corrosion on the smooth surfaces.

Exposure of the solutions to the materials only took place on weekdays. The metal coupons and the concrete were removed from the solutions over the weekend. The two days of the week that the samples were not in solutions were not factored into the corrosion rate calculations.

Preparation of Solutions and Description of the Storage Conditions

CONTROL

A clean glass bottle, containing the metal coupons, was filled with city water until the coupons were fully submerged (170 g). The coupons were arranged so they had no contact with one another. The glass bottle, containing the metal coupons and the city water was stored away from UV light, at ambient temperature (70 °F) throughout the test period. A clean, white tub containing the cement sample was filled with city water until the cement was fully submerged (170 g). The plastic tub was stored out of UV light, at ambient temperature (70 °F) throughout the test period.

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Background

DBDMH is an antimicrobial solid product that finds some use as a source of HOBr that is used in animal carcass washing operations. It is a sparingly soluble product and, depending on the temperature of the water, can be used to produce a solution containing up to about 300 ppm as Br₂. HB2 is a newer and much more widely used HOBr antimicrobial carcass wash because it is easier to use and less expensive than DBDMH. When properly activated with sodium hypochlorite, hypobromous acid (HOBr) can be produced at 10 times the concentration than those available with DBDMH. Both products are used to produce carcass and meat washing solutions containing HOBr at around 220 ppm as Br₂.

Since both sources of HOBr contact ferrous metal during their use, and since both HOBr solutions come into contact with concrete floors as they drip from the carcass, it was of interest to assess the corrosiveness of both products to these materials.

HYPOBROMOUS ACID FROM ACTIVATED HB2

The instructions from Enviro Tech's HB2 label were used to activate a hypobromous acid solution (300 ppm as Br₂), in city water, using sodium hypochlorite. The activated solution was diluted using city water to a nominal 200 ppm as Br₂ solution. For each new solution activated, it was necessary to ensure no excess chlorine was present. The absence of excess chlorine was verified using Enviro Tech's modified DPD method for the determination of bromine and chlorine in solutions. A clean glass bottle, containing the metal coupons, was filled with the activated HOBr solution until the coupons were fully submerged (170 g). The coupons were arranged so they had no contact with one another. The glass bottle, containing the metal coupons and the HOBr solution was stored away from UV light, at ambient temperature (70 °F) throughout the test period. A clean, white tub containing the cement sample was filled with the HOBr solution until the cement was fully submerged (170 g). The plastic tub was stored out of UV light, at ambient temperature (70 °F) throughout the test period.

HYPOBROMOUS ACID FROM DBDMH

A mortar and pestle was used to grind DBDMH granules into powder. A 1% slurry of DBDMH was prepared in city water. It was then stirred rapidly for 20 minutes, then gravity-filtered to achieve a saturated solution of DBDMH. The saturated solution was diluted with city water to a nominal 200 ppm as Br₂ solution. A clean glass bottle, containing the metal coupons, was filled with the HOBr solution until the coupons were fully submerged (170 g). The coupons were arranged so they had no contact with one another. The glass bottle, containing the metal coupons and the HOBr solution was stored away from UV light, at ambient temperature (70 °F) throughout the test period. A clean, white tub containing the cement sample was filled with HOBr solution until the cement was fully submerged (170 g). The plastic tub was stored out of UV light, at ambient temperature (70 °F) throughout the test period.

The HOBr solutions were analyzed for Br₂ using a HACH DR/700 Colorimeter and 10 ml Total Chlorine Pillow Packs. The HOBr solutions were tested and refreshed with a nominal 200 ppm as Br₂ solution if the solution had migrated below 170 ppm as Br₂.

Results & Discussion

Corrosion coupons were purchased in the two types of metals, 304 stainless steel and 316L stainless steel. The concrete pieces collected had at least one smooth surface to observe corrosion.

The initial weight of the metal coupons was measured with an analytical balance (accurate to 0.0001 g), and a micrometer was used to confirm the manufacturer's dimensional measurements. This data is provided in [Table 1](#) and [Table 2](#).

TABLE 1

	304 Stainless Steel	316L Stainless Steel
Dimensions (w x l x d)	1/2" x 3" x 1/16"	1/2" x 3" x 1/16"
Surface Area (in ²)	3.38	3.38
Density (g/ml)	7.94	7.98
Manufacturer Finish	Mill	Mill

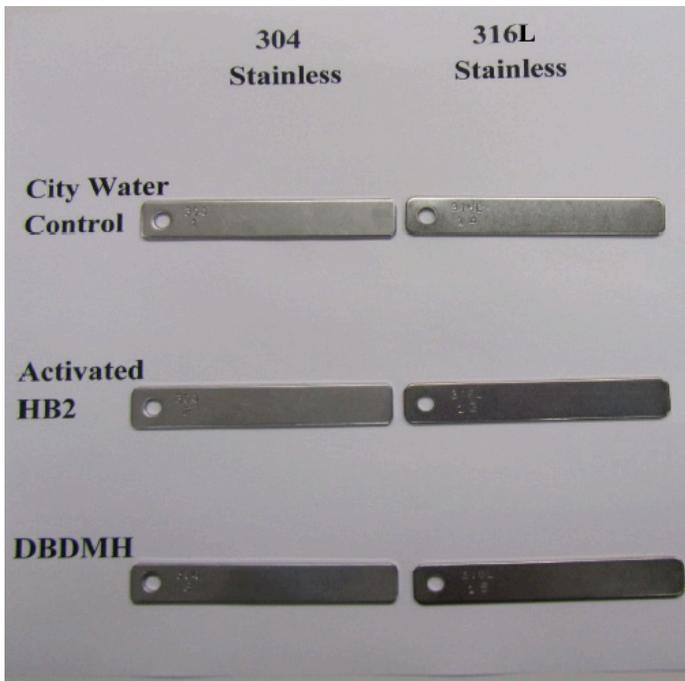
TABLE 2

Chemistry	304 Stainless Steel Initial Weights (g)	316L Stainless Steel Initial Weights (g)
Control (City Water)	10.8145	10.8295
Activated HB2 (200 ppm as Br ₂)	10.9295	10.8494
DBDMH (200 ppm as Br ₂)	10.7078	10.8277

Following 30 days of exposure to the city water control, the HOBr solution from activated HB2, and the HOBr solution from DBDMH, the coupons and concrete pieces were removed for the test, dried, weighed and photographed.

The coupons and concrete pieces are illustrated in [Figures 1](#) and [Figure 2](#).

FIGURE 1



The 304 and 316 L stainless steel coupons exposed to both sources of HOBr looked identical to the control coupons exposed to city water.

FIGURE 2



Similarly, the concrete pieces exposed for 30 days to both sources of HOBr appeared identical to the concrete exposed to the city water control. None of concrete pieces had lost any weight during the exposure period. Microscopic examination of the surfaces revealed no signs of etching or other damage. This is not surprising because both sources of HOBr are solutions that are close to pH neutral. There is no erosion or loss of weight for either DBDMH or liquid hypobromous acid.

Calculation of the Corrosion Rate

The surface area of the corrosion coupons exposed to the HOBr solutions were provided by the manufacturer. The corrosion rate for each coupon was calculated using the standard equation:

$$\text{Corrosion Rate (mpy)} = (534)(W) / (D)(A)(T)$$

Where:

W = the weight (mg) loss of the coupon over the 30 day exposure

D = density (g/ml) of the corrosion coupon

A = area (in²) of exposed surface of corrosion coupon

T = time (hr) that the coupons were exposed to the test solutions.

The data required to calculate the corrosion rate for each coupon and the calculated corrosion rate in mils per year (mpy) are organized in [Table 3](#) and [Table 4](#) for 304 stainless steel and 316L stainless steel.

TABLE 3

	304 STAINLESS STEEL		
	City Water Control	200 ppm as Br ₂ from Activated HB2	200 ppm as Br ₂ from DBDMH
W (mg)	0	1.9	0.2
D (g/ml)	7.94	7.94	7.94
A (in ²)	3.38	3.38	3.38
T (hr)	720	720	720
Corrosion Rate	0.000	0.053	0.006

TABLE 4

	316L STAINLESS STEEL		
	City Water Control	200 ppm as Br ₂ from Activated HB2	200 ppm as Br ₂ from DBDMH
W (mg)	0	0.6	0.2
D (g/ml)	7.98	7.98	7.98
A (in ²)	3.38	3.38	3.38
T (hr)	720	720	720
Corrosion Rate	0.000	0.016	0.005

Microscopic examination of the exposed metal surfaces revealed that for both sources of HOBr, the metal surfaces were indistinguishable from the control coupons exposed to city water. Thus, type of corrosion was general in nature, taking place evenly (albeit very slowly) over the exposed surface. There was no microscopic evidence of a pitting corrosion mechanism that would cause the metal to develop pinholes caused by anodic corrosion cells.

Conclusions:

The general metallurgy industry standards have ranges in place for metal corrosion rates, and are:

Very Good: rate is less than 5 mpy

Acceptable/marginal: rate ranges from 5-10 mpy

Corrosive/unacceptable: rate is above 10 mpy

Thus, the corrosion rates calculated from this experiment fell well within the Very Good range for the HOBr solutions from both activated HB2 and DBDMH. The corrosion rates for 304 stainless steel coupons were 0.053 mpy and 0.006 mpy for HOBr from activated HB2 and DBDMH, respectively. The corrosion rates for the 316L stainless steel coupons were 0.016 mpy and 0.005 mpy for HOBr solutions from activated HB2 and DBDMH. The results of this study indicate that solutions of HOBr containing up to 200 ppm as Br₂ from activated HB2 are not aggressive to stainless steel metals and concrete. The low corrosivity of HOBr from activated HB2 to both stainless steel and concrete will not adversely impact stainless steel equipment, or negatively impact concrete flooring as a result of its use.