



Evaluation Summary



Subject: MaxFlow Draft Evaluation Summary

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Objective: Preliminary evaluation of the ability of the MaxFlow coated ceramic material to disinfect *E. coli* contaminated drinking water.

Overview: MaxFlow uses a ceramic material that is impregnated with titanium and silver. This patented material produces a positively charged surface that strips electrons from bacteria and virus suspended in liquid or gas matrix that pass close to its surface. The material that was used in testing is approximately the size of a long grain of rice. According to the manufacturer, the impregnated material is not spent or used up like an absorbent or catalyst; therefore, no regeneration is necessary for its disinfection properties to remain active. Two grades of raw material were received for testing. These materials are shown in Figure 1. The material on the left was for water testing. The finer material on the right is more appropriate for use with air or other gaseous streams.



Figure 1. MaxFlow Material

Equipment Setup and Test Protocol: For the purposes of this preliminary evaluation, 10 grams of the MaxFlow material were weighed out and placed into sterile culture bottles. The culture bottles were filled with 100 mL of sterile buffer solution and inoculated with 10 mL of *E. coli* culture strain K-12, bringing the entire volume to 110 mL. The initial concentration of the *E. coli* in the culture bottle was 5.0E+06 CFU/100 mL.

The first test was performed on March 11, 2015, when the inoculated culture bottles were secured to a rotating test tube shaker as depicted in Figure 2.

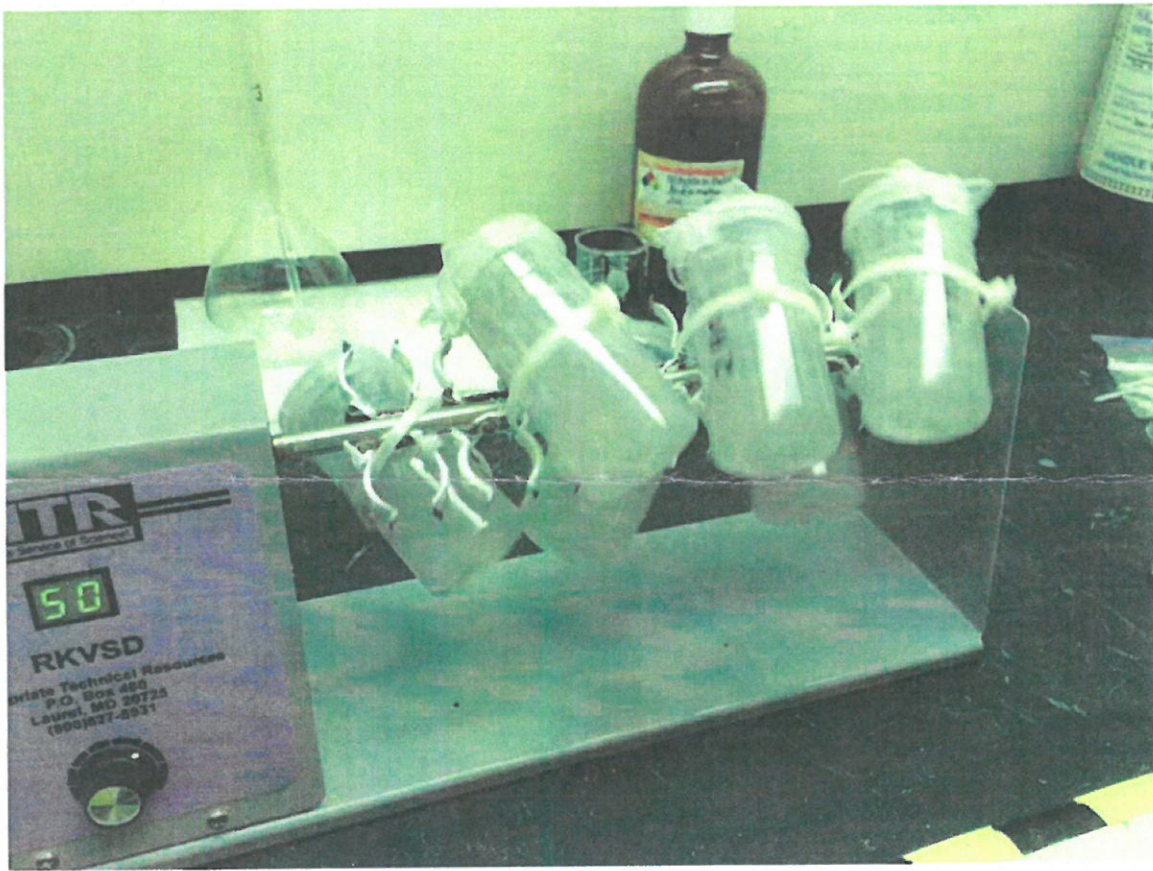


Figure 2. Laboratory Rotating Shaker

The inoculated bottles were mixed continuously at 50 rotations per minute (RPM) on the rotating shaker for 30 minutes, 1 hour, 2 hours, 3 hours and 4 hours respectively. A control bottle, not inoculated with *E. coli*, was treated in the same manner as the individual test bottles. The control sample was mixed using the rotating shaker for 4 hours.

Separately, a test using two sports-type MaxFlow water bottles with a built-in filtration module contained in the spout were also performed using the same *E. coli* mixture and concentration levels. The drinking spouts of these MaxFlow sports bottles are fitted with

a combination filter made up of activated carbon and MaxFlow media. These MaxFlow water bottles are show in Figure 3.



Figure 3. MaxFlow Water Bottles

Approximately 200 mL of the *E. coli* solution was put into these sports-type water bottles and 100 mL of that solution was squeezed through the filtration module and dispensed into sterile culture bottles. The quantity of activated carbon and MaxFlow media contained in the filtration module is not known. When the contents of the water bottle are passed through the drink nozzle, it is expected to be purified by the dual media contained in the filtration module.

All samples were then analyzed at the U.S. EPA Test & Evaluation (T&E) Facility BSL II Laboratory for *E. coli* using the T&E SOP 310 “Total Coliform and *E. coli* Analysis Using IDEXX Colilert® 18 Method.” Figure 4 shows a typical IDEXX Colilert® testing tray that has been exposed to *E. coli*. The number of positive wells are counted and that count is applied to a look-up table to determine the concentration of *E. coli* in the sample.



Figure 4. IDEXX Colilert® Test Tray

No positive tests for *E. coli* were observed for any of the timed samples tested. Table 1 summarizes the analytical results of this preliminary bench-scale study.

Table 1: Summary of *E. coli* Exposure Results to the MaxFlow Material on March 11, 2015

SAMPLE ID	Target concentration CFU per 100 mL	Final concentration CFU per 100 mL	Log reduction
Start rotating mixer			
30 minute	5.00E+06	0.00E+00	~ 6
1 hour	5.00E+06	0.00E+00	~ 6
2 hours	5.00E+06	0.00E+00	~ 6
3 hours	5.00E+06	0.00E+00	~ 6
4 hours	5.00E+06	0.00E+00	~ 6
The red and green sport drink bottles were not mixed on the rotating shaker.			
Red bottle	5.00E+06	>2.4E+03	undetermined
Green bottle	5.00E+06	>2.4E+03	undetermined
There were no viable <i>E. coli</i> remaining in the culture vials containing the MaxFlow material for any sample time through 4 hours.			
Based on expected removal, the samples from the red and green sports type water bottles were not sufficiently diluted to count the <i>E. coli</i> results.			

Following the testing performed on March 11, 2015, shown in Table 1, an additional set of testing was performed with lesser contact times (i.e., less than 30 minutes) along with an additional control sample. The results from the second round of preliminary testing are summarized in Table 2. The MaxFlow media that was used during the March 11 testing was reused for the March 16 testing. Approximately 20 grams of unused media was added to the mix to make up for the additional samples.

Table 2: Summary of *E. coli* Exposure Results to the MaxFlow Material on March 16, 2015

SAMPLE ID	Target concentration CFU per 100 mL	Final concentration CFU per 100 mL	Log reduction
Background control 10 g MaxFlow 30 minute exposure	5.00E+06	0.00E+00	~ 6
Control sample no MaxFlow media 30 minute exposure	5.00E+06	2.70E+06	0.3
Start rotating mixer			
1 minutes	5.00E+06	2.40E+06	0.3
5 minutes	5.00E+06	1.90E+06	0.4
10 minutes	5.00E+06	0.00E+00	~ 6
20 minutes	5.00E+06	0.00E+00	~ 6
30 minutes	5.00E+06	0.00E+00	~ 6
The red and green sport drink bottles were not mixed on the rotating shaker.			
Red bottle	1.00E+05	7.50E+02	2.1
Green bottle	1.00E+05	5.20E+02	2.3
There were no viable <i>E. coli</i> remaining in the culture vials containing the MaxFlow material for any sample time over 5 minutes.			

MaxFlow Material Preliminary Testing Summary – All of the culture bottles dosed with *E. coli* at 5.0E+06 CFU/100 mL were exposed to 10 grams of the MaxFlow media. For the first round of tests conducted on March 11, 2015, the exposure time ranged between 30 minutes and 4 hours. No viable *E. coli* cells remained in the bottles following the exposure to the MaxFlow media for the tested durations. Also, it was noted that during this round of testing the sample water in the bottles was fairly turbid.

For the second round of testing on March 16, 2015, the same MaxFlow media was reused with the addition of 20 grams of “new” media all mixed together for the extra set of samples. The liquid after this round of testing was not as turbid as the first round,

indicating that a media pre-rinse may be necessary to remove small particles from the virgin media.

Some of the post sampling liquid was collected and given to a chemist at the US EPA facility in Cincinnati for analysis for silver to determine if any of the ceramic coating material is leaching from the media.

A more extensive set of test conditions (e.g., with varying *E. coli* and other target biological contaminants/concentrations, MaxFlow media amounts and shorter exposure times) are necessary in order to define the media amount, exposure configuration and the contact time requirements to obtain specific log removal targets. Additional testing is also necessary to define the performance limits of the MaxFlow sports-type water bottles.