

Biofouling & Process Cleaning: A Practical Approach to Understanding What's Happening on Your Pipe Walls

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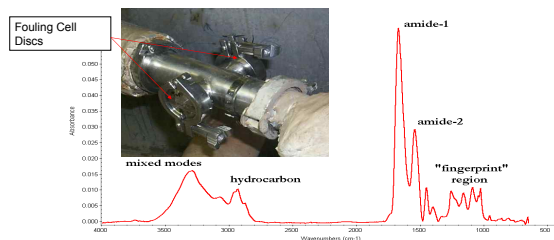
Abstract

Beer quality depends in part on the cleanliness of the liquid product transfer lines used in beer manufacturing. Traditional methods of monitoring this process health include testing the finished product (organoleptic sampling, microbiology plating) or swab sampling of interior surfaces within the process (plating, ATP analysis).

However, these means do not necessarily characterize what is growing on the inside of the transfer lines. Biofilms recovered from pipe surfaces can be difficult to grow in culture, and ATP methods require bacteria concentrations over a minimum level in order to achieve biofilm detection.

The fouling cells used in this study replaced traditional biofouling detection with surface-sensitive analytical chemistry and epifluorescence microscopy to image organisms in place on the fouling cell surface.

This approach provided an early detection of biofouling well before detection by traditional means.

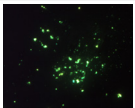
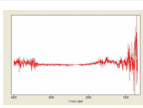
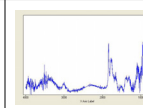
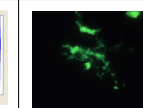
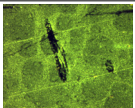
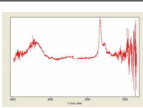
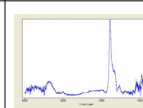
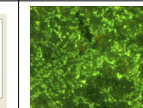
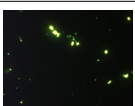
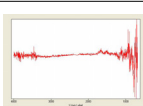
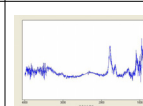
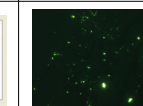
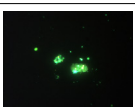
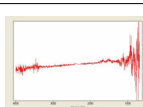
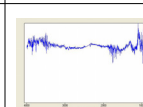
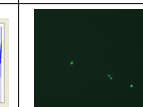
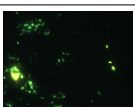
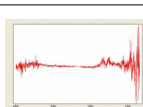
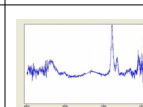


Experimental Method

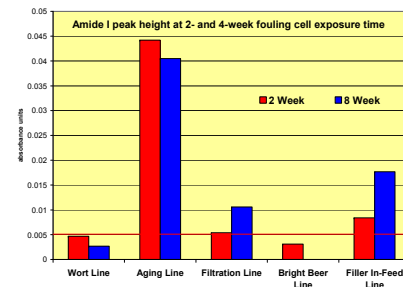
Fouling cell discs were installed in 5 locations in a brewery, from wort line to filler in-feed line. One disc was removed at 2 weeks of exposure from each location and a second disc was removed after 8 weeks of exposure. All discs were in place for various product runs and Clean-in-Place (CIP) treatments.

Upon removal from the system, the discs were allowed to drain and dry in a vertical position, then analyzed by specular reflection Fourier Transform Infrared (FTIR) spectroscopy, using a Shimadzu FTIR and Harrick Scientific specular reflection optical accessory. Once FTIR analyses was complete, the discs were stained with acridine orange (Molecular Probes, 10 mg/ml concentration, 20 min contact time at room temperature). Imaging was accomplished on an Olympus BH60 fluorescence microscope with digital camera and image processing software.

Results

	2-Week FTIR & Epifluorescence Photomicrographs		8-Week FTIR & Epifluorescence Photomicrographs	
Wort Line				
Aging Line				
Filtration Line				
Bright Beer Line				
Filler In-Feed Line				

Conclusions



- Wort Line:** Fouling in the wort line shows a change in chemistry at 8 weeks with the appearance of an ester band in the infrared spectrum. The ester component of the fouling will not clean well with the chemicals used to clean protein fouling.
- Aging Line:** The aging line has the heaviest fouling, as demonstrated by the very large amide I peaks for both 2 week and 8 week exposures, plus the obvious thick film in the epifluorescence photomicrographs.
- Filtration Line:** The filtration line showed an increase in protein fouling from 2 to 8 weeks, but there was no direct evidence of organisms by epifluorescence microscopy.
- Bright Beer Line:** The bright beer line was the cleanest line in the process, with no detectable fouling by FTIR or epifluorescence microscopy.
- Filler In-Feed Line:** The filler in-feed line amide I peak height doubled between 2 and 8 weeks of exposure; rod-shaped organisms began to appear at 8 weeks. It can be concluded that FTIR can detect a critical threshold for biofouling at 8 weeks – well before traditional microbiology detection methods.

It can be concluded that fouling cell technology provided a "window" into early detection of problems in this brewing process, detecting biofouling in the filler in-feed line before any signal was seen with organoleptic sampling, plate culturing or ATP analysis. Further, the functional group analysis capability of infrared spectroscopy offers both the ability to make informed choices of cleaning agents as well as the ability to determine the effectiveness of various cleaning agents in a CIP system.