# Tobacco Plant Extracts as Environmentally Benign Corrosion Inhibitors

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**Tests showed that extracts of tobacco plants are highly effective in preventing corrosion of two important metals—steel and aluminum—in saline environments. The extracts are biodegradable and environmentally benign and are obtained from a renewable resource with minimal health and safety concerns. They have the potential to be a cost-effective alternative to toxic corrosion inhibitors.**

Extracts of tobacco plants are effective, environmentally friendly corrosion inhibitors. Corrosion inhibitors are compounds that are commonly added in small quantities to an environment to prevent corrosion. Because some corrosion inhibitors present environmental and health risks, there is a demand for less toxic corrosion inhibitors. Extracts from tobacco plants can be very effective in reducing the corrosion rates of several metals in saline (chloride-containing) solutions, often resulting in a greater inhibition effect than chromates.[1-3] The extracts offer several advantages over chromates (which are illegal to use in the U.S.) and related inhibitors: 1) they are biodegradable and environmentally benign with minimal health and safety concerns; 2) they originate from a renewable biosource; and 3) they are cost-effective.

Tobacco plants produce ~4,000 chemical compounds—including terpenes, alcohols, polyphenols, carboxylic acids, nitrogen-containing compounds, and alkaloids[4]—that may exhibit electrochemical activity, such as corrosion inhibition. The many compounds present in the extract make identifying the active inhibitive components difficult, if not impossible. Consequently, the focus of this effort has been to develop an inexpensive natural extraction product that effectively inhibits corrosion.

## Corrosion Inhibition Efficacy

### INHIBITION OF GALVANIC COUPLES

Numerous types or strains of tobacco exhibit excellent corrosion inhibition. Neither the quality nor form of plant material is an important factor in inhibition efficacy. Figure 1 shows representative results. Most tobacco samples gave inhibition efficacies of more than 90%, with some as high as 99.8%. The effectiveness of the corrosion inhibition does not appear to be dependent on the quality of the tobacco. Both low-quality tobacco material (dust, scrap, and KY B005 tree tobacco) and high-quality material (Little Crittenden, VA tobacco, KY Burley leaf, NC129 Burley, and KY 171) give similar results. This finding is important because low-cost and scrap tobacco material (dust, twigs, and stems, or low-quality leaves) can be used and can be highly effective in reducing corrosion.

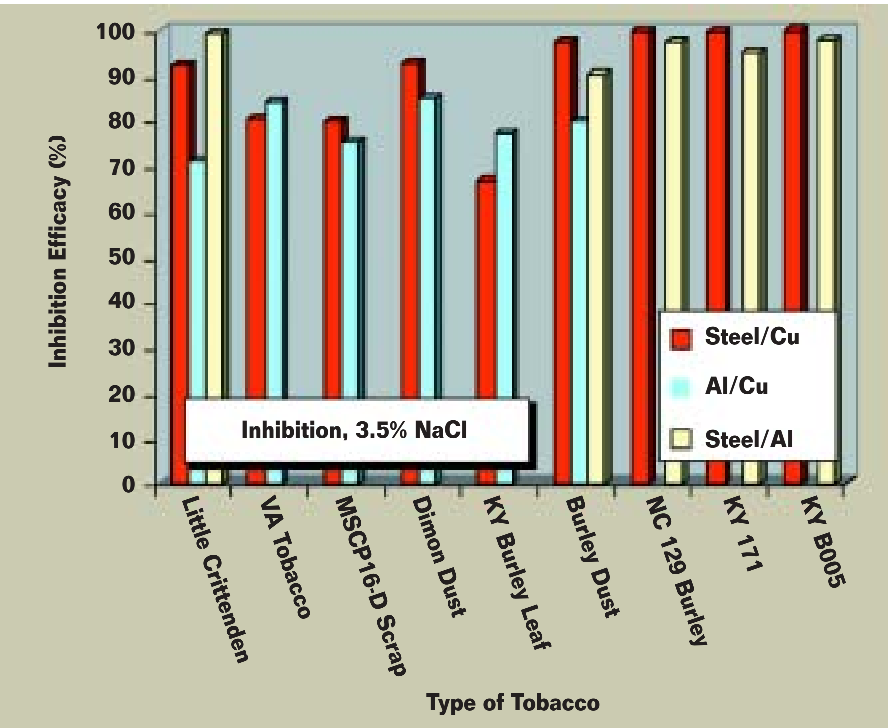
These data also indicate that inhibition efficacy is not limited to a specific metal. The steel/Cu, Al/Cu, and steel/Al galvanic couples showed similar corrosion inhibition for most tobacco samples. Averaged over all tobacco samples, the corrosion inhibition efficacy is 96% for steel/Al, 90% for steel/Cu, and 79% for Al/Cu. Previous results indicate that this efficacy is equal to or better than that provided by chromates.[1-3] Other measurements of these metals (polarization resistance and visual inspection of immersed specimens) individually show similar results. The tobacco extract appears to be a universal corrosion inhibitor, much like chromates, and unlike other organic corrosion inhibitors that are effective for only one or two metals.

Figure 2 shows corrosion inhibition efficacy of the Burley Tobacco Dust extract at different extract concentrations for the three galvanic couples. Most of the corrosion inhibition is achieved between 0.03 and 0.1% of extract, with only small improvements at 1% or higher. Even at 0.01% (100 ppm) significant inhibition is seen, especially for the Al-containing couples. Note that the extract concentrations presented are the total concentrations of the material extracted from the tobacco material; the concentrations of the active inhibitive component(s) are unknown but are believed to be much lower.

### WEIGHT LOSS TESTS

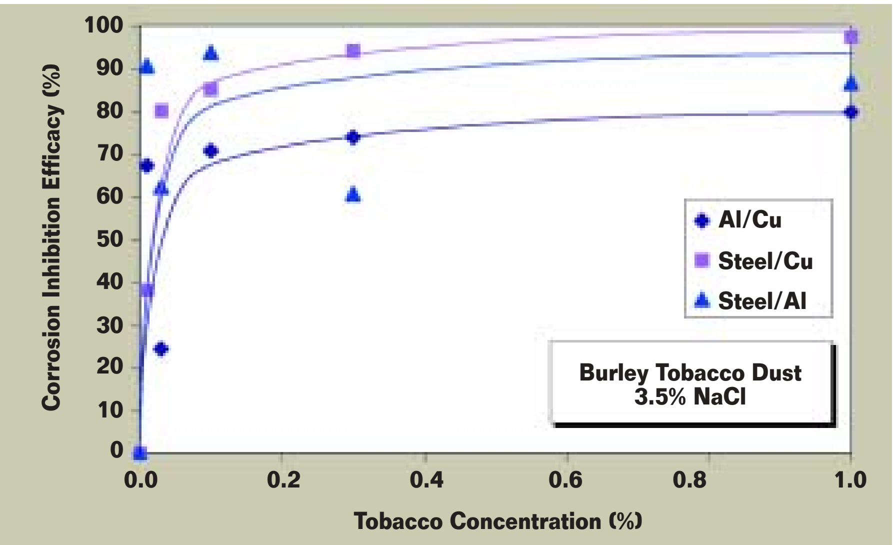
Another means of detecting corrosion and corrosion inhibition is weight loss. Figure 3 shows the weight loss of Al and steel panels immersed in salt water with and without tobacco extract added. The inhibition of corrosion by the tobacco is clear. Inhibition efficacies of ~90% or more were obtained through the immersion time; they compare favorably with those obtained from the zero-resistance ammeter (ZRA) measurements above. The slight weight gain (negative weight loss) of the Al panel likely resulted from a thin deposit of tobacco forming on the surface of the Al.

**FIGURE 1**




Inhibition efficacy of tobacco extracts for steel/Cu, Al/Cu, and steel/Al galvanic couples, as measured by a ZRA. Different tobacco strains and qualities are shown.

**FIGURE 2**

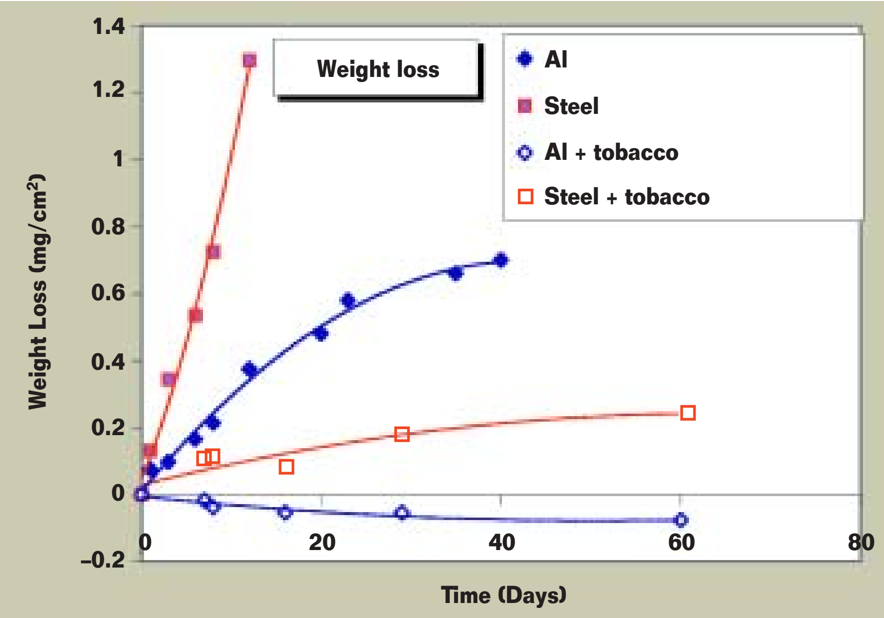



Corrosion inhibition efficacy, as determined by ZRA current measurements, for the Al/Cu, steel/Cu, and steel/Al galvanic couples immersed in salt water with different concentrations of tobacco extract.

### IMMERSION PANELS

Perhaps the most impressive visual display of corrosion inhibition by the tobacco extracts is the immersion of bare and scribed painted panels in salt water with and without tobacco extracts. Figure 4 shows bare Al panels after 62 and 220 days. At both times (and at much earlier times), the panel in the salt water without tobacco was

FIGURE 3



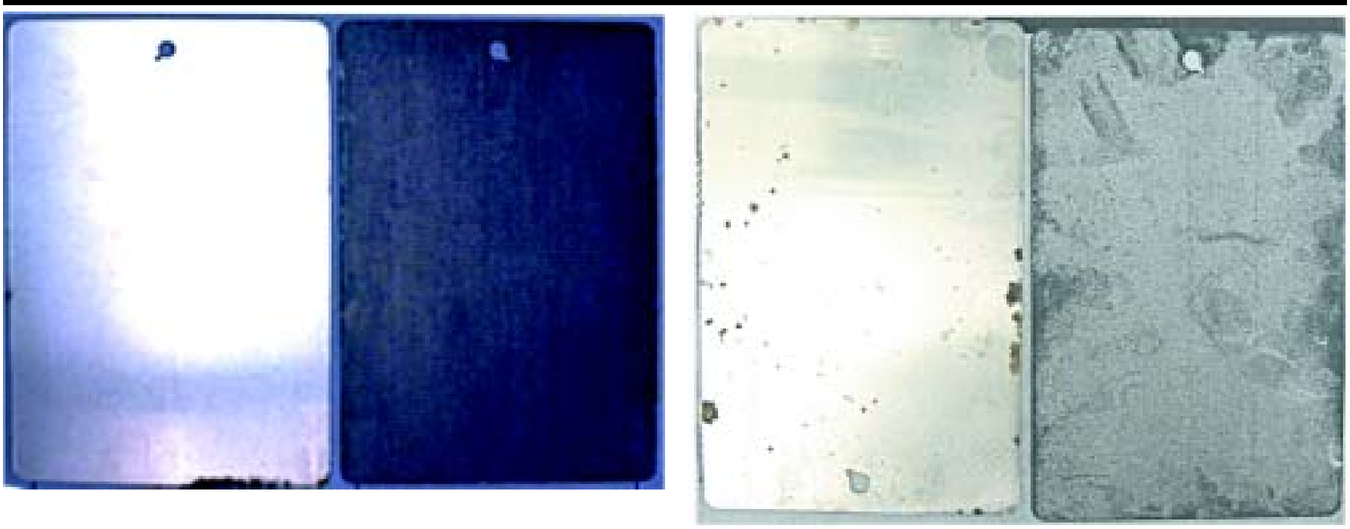

Weight loss of Al and steel panels immersed in salt water with and without tobacco extract.

heavily pitted and showed extensive corrosion. After 62 days, the Al panel in the tobacco solution was still bright and shiny. After 220 days, the panel had a thin layer of tobacco deposit. The deposit tends to give the surface a golden luster, which does not represent corrosion. First noted after 127 days, it is most pronounced in the 3% tobacco solution but occurs to a lesser extent in the 0.3% solution shown. The 220-day specimens also exhibited isolated areas of localized corrosion near the edges. These corroded areas likely resulted from a combination of cold working from the panel-forming process and inclusions in the metal. Little or no general or pitting corrosion is seen away from the panel edges.

The steel panels had similar results (Figure 5). Even after 127 days, the panel immersed in salt water plus tobacco extract showed very little corrosion. In contrast, the panel immersed in salt water without tobacco was heavily corroded as the corrosion began soon after the panels were immersed. As with the Al panels, a tobacco deposit formed on some of these panels—especially those with 3% tobacco extract. With the steel panels, some corrosion was observed after 220 days even with tobacco. The tobacco solution had not been replaced during this time, suggesting that some replenishment might be needed for extended periods of time.

Additional steel panels were painted with three different household primers (a water-based primer and two oil-based primers). To make the experiment as aggressive as possible and provide the most stringent test of the inhibition efficacy of the tobacco extract, no topcoat was added over the primer. Salt water solutions with both 3 and 0.3% tobacco extract concentrations were used. Both were effective, indicating that the lower inhibitor concentration is adequate for this application. With the higher inhibitor concentration, after a period of time there was a brown deposit of tobacco material on the paints. With the lower concentra-

FIGURE 4

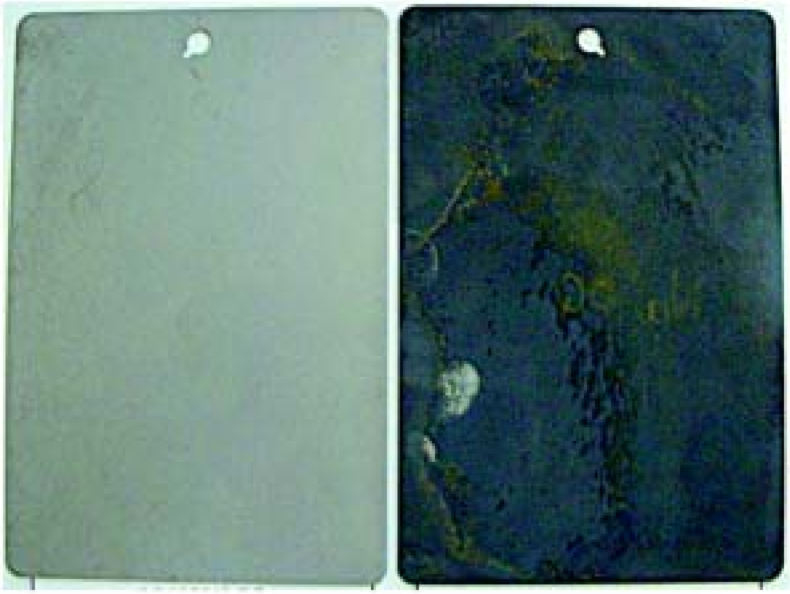


Al panels immersed in salt water with and without 0.3% tobacco extract. Left pair—after 62 days immersion. Right pair—after 220 days immersion. The left-hand panel of each pair was immersed in the tobacco-inhibited solution. The right-hand panel of each pair was immersed in the uninhibited solution.

tion, any deposit was greatly reduced—if present at all.

Figure 6 shows selected panels after 192 days of immersion. In each case, there is little or no rust from the scribes on specimens immersed in the tobacco solutions (upper pair of each set). As expected, the water-based primer (without tobacco in solution) exhibited the most rust as rust originated from the scribe within days of immersion. The oil-based primers worked better without the tobacco extracts, although there still was significant rusting at the scribed area. This rust is greatly reduced with tobacco, with almost no corrosion or undercutting observed at the scribe.

FIGURE 5



Steel panels immersed in salt water with (left) and without (right) tobacco inhibitor for 127 days.

## Conclusions

Extracts of tobacco plants are very effective corrosion inhibitors in salt water. They provide corrosion protection to steel and Al and to galvanic couples of these metals with themselves or with Cu. Compared to chromates, the extracts are environmentally benign, biodegradable, and nontoxic. Additionally, the tobacco extracts are obtained from a renewable source and can be inexpensive with the use of waste tobacco material.

## Acknowledgments

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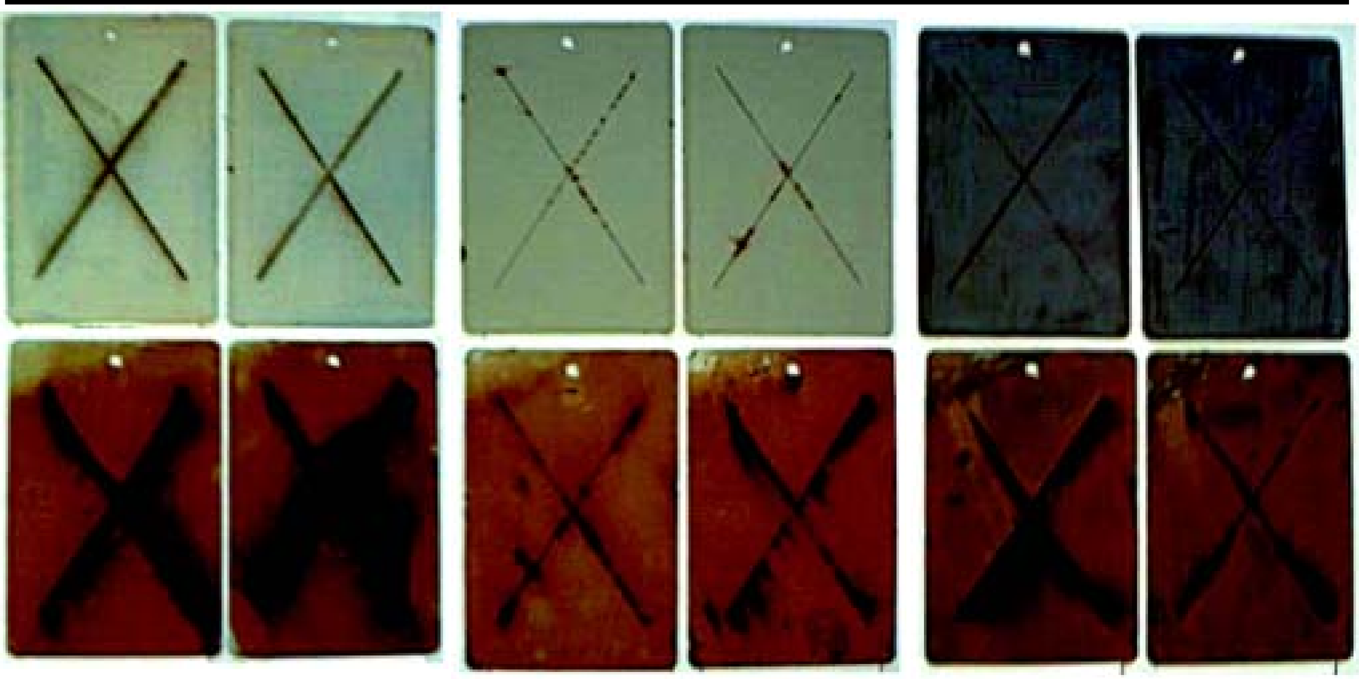
FIGURE 6



Scribed, painted steel panels immersed in salt water for 192 days. Side-by-side pairs are duplicates. Top pairs of each set were immersed in the salt + tobacco solution. Bottom pairs of each set were immersed in the salt solution without tobacco. Left—water-based primer. Center—oil-based primer #1. Right—oil-based primer #2.

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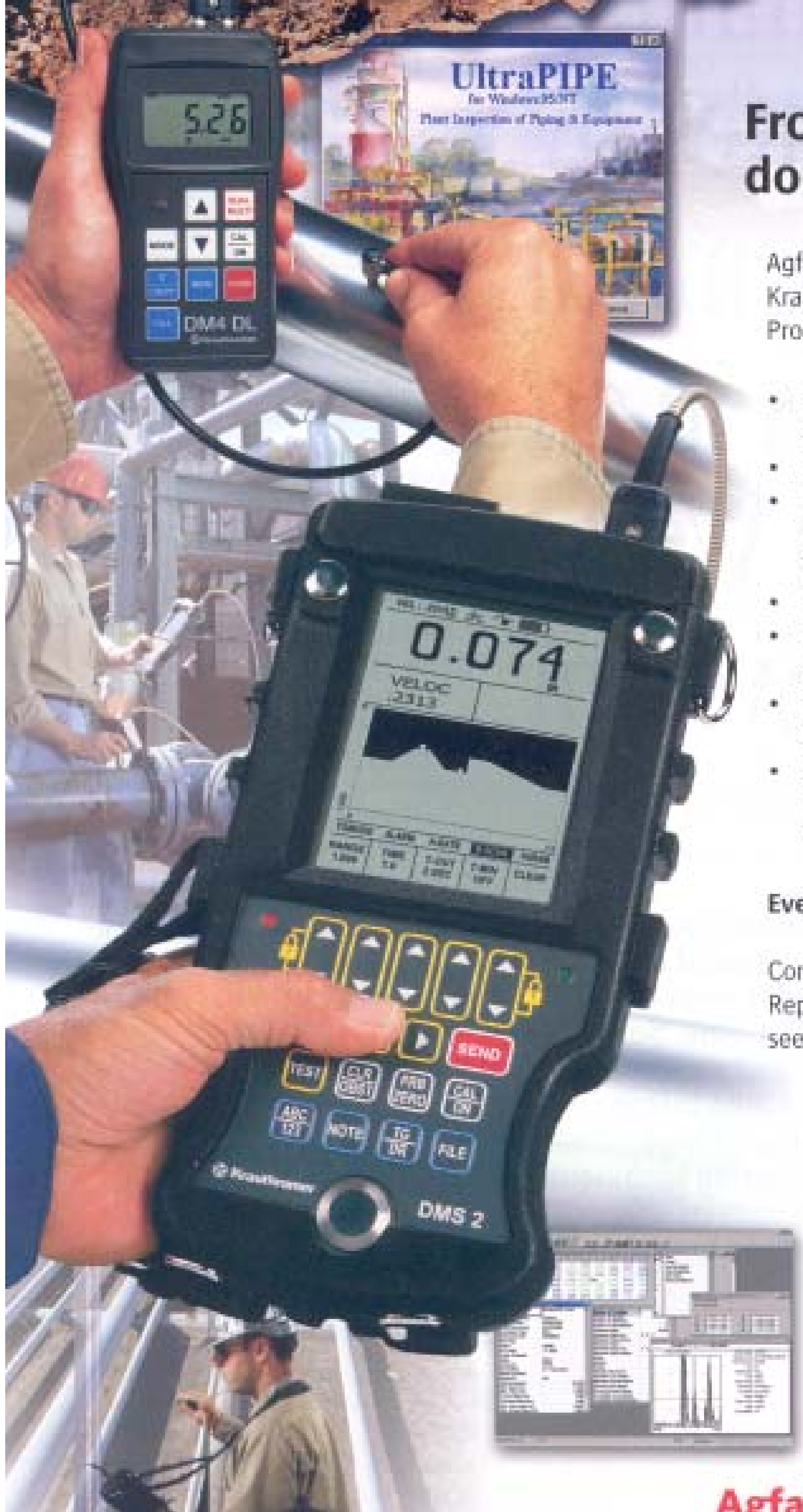


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