

the alkalinity of sodium silicate, even a small concentration can raise the pH of the rinse solution to such a level that aluminum becomes corroded despite the inhibiting effect. The pH of a solution that contains a high concentration of sodium silicate can be decreased by adding sodium tetraborate. On the other hand, the addition of sodium tetraborate increases the concentration of dissolved solids to such a high level that cosmetic staining becomes an issue.

One suitable compromise calls for establishing the pH of the rinse solution at 9.5 and including sodium silicate at a concentration of 50 ppm Si. This

choice is justified by the observation that at a pH of 9.5, the rates of corrosion of both steel and aluminum are relatively low, and, therefore, only a minimal concentration of corrosion inhibitor is needed. By reducing the concentration of silicate, one reduces the amount of sodium tetraborate needed to buffer the rinse solution, thereby also reducing the level of cosmetic staining.

The figure depicts the effectiveness of the corrosion inhibitor in blind holes in D6AC steel specimens. In other tests on D6AC steel specimens, rates of corrosion in water containing this corrosion inhibitor were found to be approximately

$10^{-5}$ × those in deionized water. In similar tests on 7075-T73 aluminum specimens, rates of corrosion in water containing this corrosion inhibitor were found to be only slightly greater than those in deionized water. In still other tests, the strengths of adhesive bonds on steel and aluminum specimens rinsed with corrosion-inhibited solutions were found to be approximately equal to those on specimens rinsed with deionized water.

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## Wipes, Coatings, and Patches for Detecting Hydrazines

With suitable reformulation, other hazardous substances could also be detected.

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Three color-indicating devices have been conceived as simple, rapid, inexpensive means of detecting hazardous liquid and gaseous substances in settings in which safety is of paramount concern and it would be too time-consuming or otherwise impractical to perform detection by use of such instruments as mass spectrometers. More specifically, these devices are designed for detecting hypergolic fuels (in particular, hydrazines) and hypergolic oxidizers in spacecraft settings, where occasional leakage of these substances in liquid or vapor form occurs and it is imperative to take early corrective action to minimize adverse health effects. With suitable redesign, including reformulation of their color indicator chemicals, these devices could be adapted to detection of other hazardous substances in terrestrial settings (e.g., industrial and military ones).

One of the devices is a pad of a commercially available absorbent material doped with a color indicator. The absorbent material is made from 70 percent polyester and 30 percent nylon and can absorb about eight times its own weight of liquid. The color indicator is a mixture of conventional pH color indicator chemicals. Hydrazine and monomethyl hydrazine, which are basic, cause the color indicator to turn green. In the original intended application, the

pad is wiped on a space suit that is suspected of having been exposed to leaking monomethyl hydrazine during a space walk, before the wearer returns to the interior of the spacecraft. If the wiped surface is contaminated with hydrazine, the pad turns green. In addition, the pad absorbs hydrazine from the wiped surface, thereby reducing or eliminating the hazard. Used pads, including ones that show contamination by hydrazine, can be stored in a sealed plastic bag for subsequent disposal.

The second device, which has been proposed but not yet developed, would comprise a color indicator material in the form of either a coating on a space suit (or other protective garment) or a coating on a sheet that could be easily attached to and detached from the protective garment. The coating material would be a hydrogel doped with a suitable pH indicator. The hydrogel would also serve to maintain a level of moisture needed to support the chemical reaction mentioned in the next sentence. In addition to changing color to indicate the presence of any hypergolic fuel (which is basic) or hypergolic oxidizer (which is acidic) that might splash on the space suit, the pH indicator would also react with the hypergolic fuel or oxidizer and thereby bind it.

The third device is a color dosimeter for detecting hydrazine liquid or vapor



A Porous Cellulose Disk Loaded With  $\text{KAuCl}_4$  changes color upon exposure to hydrazine.

coming from microscopic leaks. This device is designed to satisfy several requirements specific to its original intended use in the auxiliary power unit of the space shuttle. These requirements include stability under vacuum, stability at moderate temperature, fast and irreversible change in color upon exposure to hydrazine, and visibility of the color change through polyimide tape. The device is a patch comprising a porous glass-fiber or cellulose patch loaded with potassium tetrachloroaurate (III) [ $\text{KAuCl}_4$ ], which changes color from yellow to purplish gray upon exposure to hydrazine (see figure).

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