Detection of the Interaction between an Iron Surface and Organic Molecules by Means of Infrared Absorption

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For the surface treatment of steel with organic substances or polymers to increase corrosion resistance and to improve appearance, the selection of materials with a strong enough interaction with the surface appears to be an increasingly significant problem.

The authors have tried to use an infrared absorption method to observe the anomaly in the absorption bands which might be due to the interaction of the iron surface with some organic substance.

Examining the reflection of infrared light from organic films covering the surface of the metal plate, the intensity of the infrared light is not sufficient to serve for the present purpose. To increase the intensity, fine iron powders are mixed with organic substances.

The rouge (iron oxide) 0.2 to 0.5 μ in diameter was reduced to iron with pure hydrogen at 500°C for 4 hr., cooled in a flow of hydrogen, and replaced in pure ethyl alcohol. The gradual evaporation of alcohol at room temperature gave iron powders which are stable when exposed in air.

The absorption bands of mixtures of the powders and organic substances, described later, measured by means of an infrared spectrophotometer with an NaCl prism (e. g., Hitachi EPI-2) did not provide data enough on the presence of interaction.

A single-beam spectrophotometer with the grating system (Perkin-Elmer 112G) gave the following results.

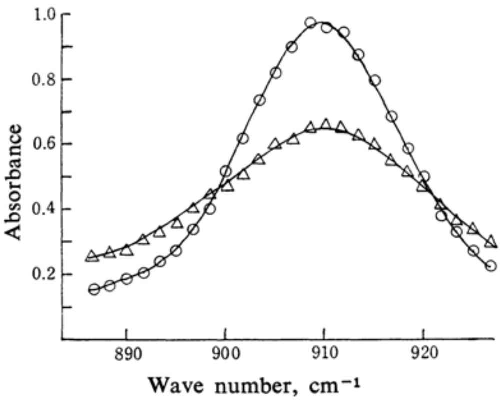

Fig. 1. Infrared absorption of styrene and styrene-iron mixture.

—○— Styrene —△— Styrene+Fe

Figure 1 shows the absorption bands of purified styrene and the reduced iron powders wetted completely with styrene. Table I gives the wave number, calculated from the micrometer readings (GD), of the main absorption bands and the discrepancy of wave number between styrene and the mixed system; no change in the absorption bands has been observed.

TABLE I. INFRARED ABSORPTION OF STYRENE AND STYRENE-IRON MIXTURE

	Wave number, ν (cm^{-1}) and intensity		
Styrene	1629.5(m)	1600.5(w)	908.2(s)
Styrene+Fe	1629.0	1600.2	908.4
$\Delta\nu$ (cm^{-1})	0.5	0.3	0.2

Figure 2 and Table II show similar results for vinylpyridine and the iron-vinylpyridine system. It is recognized that the strong absorption at 832 cm^{-1} for vinylpyridine splits into two bands at 830 and 837 cm^{-1}. The discrepancy of wave number between the mixed system and the vinylpyridine monomer is apparently over the expected experimental error, confirmed by a separate examination for vinylpyridine, of approximately 0.7 cm^{-1} in the region of 830~840 cm^{-1}.

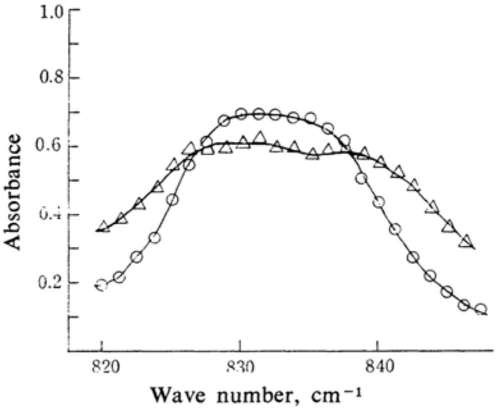

Fig. 2. Infrared absorption of vinylpyridine and vinylpyridine-iron mixture.

—○— Vinylpyridine

—△— Vinylpyridine+Fe

TABLE II. INFRARED ABSORPTION OF VINYLPYRIDINE AND VINYLPYRIDINE-IRON MIXTURE

	Wave number, ν (cm^{-1}) and intensity		
Vinylpyridine	1595.1(s)	1545.6(m)	832.4(s)
Vinylpyridine +Fe	1595.1	1546.2	837.2 830.4
$\Delta\nu$ (cm^{-1})	0	0.6	4.8 2.0

This may be attributed to the fact that the absorption in the region of 832 cm^{-1} corresponds to the out-of-plane bending vibration of the skeletal CH bonds. The splitting of the band might be due to an effect of the interaction between the iron surfaces and, possibly, the pyridine group. However, a doubt still remains because the intensity of the two split bands is almost identical, although it is presumed that only a fraction of the vinylpyridine monomer is affected by the iron surface.

It was purposely confirmed further that the coated film of polystyrene from the polymer solution on the steel plate adheres less than the similar film of the copolymer composed of styrene and vinylpyridine, on which results a separate report will be published elsewhere.

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