

regard to the higher animals, it has been considered to be of no physiologic importance, as it has not been demonstrated in their tissues (spectrographically).

An interesting and significant fact is that the vanadium content of mineral oils may cause corrosion of oil-heated boilers. Here it is probably a matter of catalytic action, with oxidation of sulfur dioxide to sulfur trioxide, and to some extent also of formation of vanadates.

Vanadium appears to have a catalytic action also on some enzymic processes. Vanadates increase the fermentation of hexosediphosphoric acid with yeast extract, and the uptake of oxygen in a suspension of liver from rats or guinea pigs. On these investigations are based some authors' belief that in man the ill effects of vanadium can be attributed to the damage caused to the metabolic processes in the tissues, which, however, has not been demonstrated in the present or any other investigation.

Several experiments to determine the toxicity of vanadium compounds have been made, mostly with vanadium salts. Some workers in the past century reported almost the same results obtained by injecting vanadates and vanadium pentoxide into animals: paralysis, absence of reflexes, convulsions, enteritis, slower breathing, impaired action of the heart and, eventually, death. Ammonium vanadate *per os* produced somnolence, coma, convulsions and death in rabbits. Autopsy of these animals showed small hemorrhages with ruptures of the smallest vessels of the brain and inflammation of the bronchi, the renal tubules and the mucosa of the large intestine. Doses of 368 p.p.m. of sodium vanadate *per os* were fatal in rats, Daniel<sup>1</sup> (1938) described the acute poisoning among the animals as follows: anxiety reactions, bleeding from the nose, intestinal hemorrhage, diarrhea, paralysis of the hindquarters, dyspnea and convulsions. The chronic poisoning occasioned by tolerable doses is manifested in similar, although less striking, symptoms, combined with loss of appetite and emaciation. Microscopic examination of the poisoned animals showed acute enteritis, fatty degeneration of the liver, swelling and local hemorrhages of the lungs, slight parenchymatous degeneration of the renal tubules and, finally, pathologic changes in the adrenals, the spleen, the bone marrow and the brain, which, however, were probably not of a significant nature. Heimberger<sup>2</sup> (1929) had reported similar symptoms after injecting vanadates into mice and cats. Autopsy showed hyperemia of the digestive organs in many cases and edema of the lungs in some cases but otherwise nothing remarkable (no histologic examinations were made). Of greater interest in this connection are Heimberger's inhalation experiments with vanadium pentoxide on cats. She found that this compound is tolerated by the animals in low concentration (0.043 mg. per liter) for at least three hours, whereas a ten or a hundred times higher concentration kills the animal within minutes or hours in many cases. The symptoms are described as follows: accelerated breathing, sneezing, coughing, rattling sounds, and also loss of appetite and bloody diarrhea. Autopsies showed mucous-catarrhal phenomena in the gastrointestinal tract, with small gastric ulcers in a few cases, and in the respiratory organs, with edema of the lungs in some cases.

1. Daniel, E., and Lillie, R. D.: Experimental Vanadium Poisoning in the White Rat, Pub. Health Rep. 53:765, 1938.

2. Heimberger, C.: Injektionsversuche an Katzen und Mäusen mit Vanadinsalzlösungen und Staubinhalationsversuche an Katzen mit Vanadiumpentoxyd, Dissertation, Würzburg, 1929.