THE ACIDIC PROPERTIES OF MnO_4^-

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The principal objection raised by Shatenshtein [2] and other authors to the concepts of acids and bases which I have developed [1] is that I erroneously regard oxidation-reduction processes as a special case of acid-base interaction. In an earlier review Luder [3], in particular, had regarded such an approach to oxidation-reduction processes as the main defect of my theory. In a recent publication Luder and Zuffanti [4] generally favor my theory, pointing out that the acid-base theory of Lewis in its original formulation did not exclude oxidation-reduction processes, but that they had attempted to broaden Lewis' theory by including oxidation-reduction processes in it. A similar development of my ideas is found in a paper by Charlot, Wolff and Lacroix [5]. In spite of this, however, Luder and Zuffanti persist in their criticism, asserting that although a close relationship exists between acid-base and oxidation-reduction processes, the relationship " is not of the type put forward by Usanovich" [6]. As a specific example these authors adduce the behavior of MnO_4^-: "for example, the permanganate ion is a strong oxidizing agent but not an acid".

I should now like to consider this example since it can be demonstrated with particular clarity in this case that no sharp division can be drawn between acid-base and oxidation-reduction processes.

It can be seen from the over-all equation for the transformation of potassium permanganate into manganate [7] that this oxidation-reduction process is at the very same time an acid-base interaction:

$$2KMnO_4 + 2KOH \longrightarrow 2K_2MnO_4 + H_2O + O.$$

The oxidation-reduction process is accompanied by the disappearance from the solution of the caustic alkali.

The modern stoichiometric equation of this reaction [8] takes the form:

$$4MnO_4^- + 2H_2O \longrightarrow 4MnO_4^{--} + O_2 + 4H^+.$$

We see from this equation that the oxidation-reduction process is accompanied by acidification.

It may be thought that the oxidation-reduction process and the acid-base interaction are separate stages in the reaction. In reality this is not so. Duke [8] recently investigated this reaction and reached the conclusion that the first stage is the following equilibrium:

$$MnO_4^- + H_2O \rightleftharpoons MnO_4^{--} + OH + H^+.$$

The MnO_4^- functions simultaneously as an oxidizing agent, converting water into free hydroxyl, and, as an acid, increasing the hydrogen ion concentration.

Therefore Luder and Zuffanti are in error when they assert that the permanganate ion is an oxidizing agent but not an acid. We see that the permanganate ion is capable of exhibiting oxidizing and acidic properties simultaneously.

SUMMARY

It is shown that the permanganate ion while functioning as an oxidizing agent behaves simultaneously like an acid.

LITERATURE CITED

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