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Walter J. Sweet
Iowa State College

O. R. Sweeney
Iowa State College

MODIFICATION OF BLOOD BY ZEOLITES FOR TRANSFUSION PURPOSES

WALTER J. SWEET AND O. R. SWEENEY

Richard Lower made the first blood transfusion in 1665, but the wide use of the technique in medicine is quite recent. One of the difficulties lay in the coagulation of the blood during the transfer. Accordingly, the blood is generally treated with sodium citrate to prevent this.

It is known that calcium in the blood has something to do with the coagulation and probably with the agglutination. It was decided to study blood from which the calcium had been removed. To remove the calcium we adopted the principle used in removing calcium from hard water, that is, passing it over a zeolite. Blood is viscous—especially coagulated blood—hence it was necessary to use suction to force it through the tube filled with zeolite. The tube was attached to a filter flask which in turn was attached to a filter pump. In this way the blood was passed through the zeolite bed successfully. The zeolite used was the sodium modification. The reaction is:

$$\text{Ca salts} + Na_2Ze \rightarrow CaZe + Na_2 \text{ salts}$$

The sodium remained in the blood. The calcium, which replaced the sodium, was retained by the zeolite.

Most of the blood tested was supplied from the Veterinary Department of the Iowa State College, and was taken from living horses. One sample came from pigs slaughtered in the Meat Laboratory at the Iowa State College. Samples of horse blood were citrated for comparative measurements. Other samples were allowed to coagulate. Still others were passed immediately over, or treated with, zeolite. Only one sample of pig blood was taken: One part was treated with zeolite immediately, another part was allowed to coagulate before being treated. On standing, the samples which were citrated and those which were treated with zeolite showed little or no change. The untreated blood deteriorated rapidly after coagulation.

The zeolites used were the commercial product called "Zeocarb", and an aluminum silicate prepared in the laboratory which was similar to the "high capacity" base exchange zeolites sold in the open market. The low capacity zeolites, and the recent organic zeolites have not been used as yet. A Leeds Northrup Company hydroquinone electrode was used to determine the pH of the blood.

If the blood were poured over the zeolite, it would not flow through under gravitational force alone. If mixed first with citrate it could be forced through. It was not found possible to force the blood through the zeolite by arterial force. By the suction device the blood flowed through satisfactorily. The clotted blood could be mechanically mixed with small quantities of zeolite, stirring the mass with a glass rod, after which it could be filtered with suction. The filtrate gave results identical to those of the unclotted blood which had been sucked

through the zeolite. In some cases not all of the fibrin was redispersed, however.

The blood that had been passed through the bed of zeolite had entirely lost its property of coagulation. When examined under a microscope it showed no evidence of having a corpuscular suspension structure, but was homogeneous.

A sample of the zeolite treated blood was set aside, under sterile conditions, and allowed to stand for several weeks at room temperature. This was at summer heat, often as high as 100°F. There was no evidence of deterioration, and the blood appeared to be exactly the same as when set aside.

Calcium determined by the standard method as given by Meyers in "Practical Chemical Analysis of Blood" was as follows:

Citrated Blood Mg. of calcium to 100 cc. of blood	Zeolite Treated Blood Mg. of calcium to 100 cc. of blood
9.5	4.0
9.3	3.9
9.0	4.1

Hydrogen Ion Concentration of Blood Treated with Zeolite

Determination Number	pH
1	6.8
2	7.0
3	6.8

Blood treated with both types of zeolite gave the same pH value.

There remains to be studied the effect of various types of zeolites, especially the organic, on the pH of the blood. Since the zeolite exchange can be made with almost any mineral base, the pH may be controlled by substituting sodium, potassium, caesium, lithium, magnesium, rhodium, and the like. Lithium would be particularly interesting since it has valuable medicinal properties. Also, rhodium is reputed to be effective in pyemia. The replacement in the blood compound instead of an admixture in the blood stream should be worthy of careful study by the physician.

Zeolitic treated blood from horses and pigs seemed to be compatible. That is, no sedimentation took place on mixing. Further study may show that zeolitic treatment may make all four types of human blood compatible, thus simplifying the blood bank storage. Zeolitic treatment may so modify animal blood as to make it useful.

Much work remains to be done. Of course, medical men will have to study the use of these treated bloods. We are only reporting here the interesting observations on the zeolitic treated blood.

The normal pH for blood is from 7.35 to 7.43. Van Slyke suggests the range, compatible with life, lies between 7.0 and 7.8 approximately. Of course, the pH could be raised artificially if need be.

The study indicates that better results are obtained from fresh batches of zeolite each time rather than regenerated zeolite.

IOWA STATE COLLEGE,
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