

and under nitrogen. One might question the precision of the testing technique.

In my opinion, the question of the chemical state of ^{99m}Tc in biomedical products remains unanswered and Benjamin's reduced pertechnetate-metal ion complex theory (*Int J Appl Radiat* 20: 187-194,

1969 and *J Nucl Med* 11: 147-154, 1970) might be correct.

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THE AUTHORS' REPLY

We wish to thank Dr. Hupf for taking the time to review our recent publication in detail. For determining the chemical state of a carrier-free substance physical measurements such as resonance and spectroscopy are difficult to carry out because of problems with impurities and sensitivity at the carrier-free level. We therefore felt that using collected chemical data might more easily suggest the chemical state of ^{99m}Tc ; however, since this involves inferences from all the data, no single experiment would offer sufficient proof. Perhaps we did not emphasize this point enough. We wish to summarize here the collected chemical data which led to our conclusion that ^{99m}Tc is reduced in biomedical products and to answer Dr. Hupf's questions within this framework:

1. The electrolysis experiments: We believe that the data from the experiments described in the paper show that the dialysis tubing prohibits incorporation of technetium in chelates prepared from the cathode solution, and that this is not consistent with a zirconium pertechnetate complex since the cathode solution contained zirconium. In an unreported experiment, we could not chelate technetium by mixing pertechnetate with a strongly acidic solution of zirconyl chloride followed by chelate addition and pH adjustment to 7.

2. The gel chromatography data: Gel chromatography data indicate that a form of technetium is adsorbed to the Sephadex column. The key here is that both metallic and nonmetallic reducing agents can be used to prepare this form. This rules out coprecipitation of pertechnetate with a metal oxide. The data in Table 4 of our paper indicate that technetium can also be incorporated into chelates in the absence of metal. The chelate yield, as Dr. Hupf points out, is much lower than for metallic reducing agents, but the yield should be 0% if a metal is required. A subsequent paper (1) from this laboratory gives a likely explanation for the quantitative difference in yields, namely that the ability of different reducing agents to produce different oxidation states of technetium influences the chelate yield. Ferrous and stannous ion seem to produce high yields of the IV oxidation state, whereas the HCl-HI system produces lower but still significant yields of the IV state and consequently lower yields of the chelate.

In addition, the molar amount of chelating agent was not maximal in this case.

The point made by Dr. Hupf concerning the work of Conrad and Schade is well taken, and it was one of the reasons we thought that the use of nonmetallic reducing agents would provide more definitive data by eliminating the possibility of coprecipitation. The systems used by Conrad and Schade are not completely analogous to ours: they use equimolar amounts of iron and ascorbic acid whereas we use large excesses of ascorbic acid and much smaller amounts of iron. Even with their unfavorable conditions the ferrous ascorbate system at pH 6.5 would yield 95% soluble iron according to Fig. 4 of their paper. Beyond that, comparison is difficult because of sparse experimental description. The ^{14}C ascorbic acid data published for a system comparable to ours (2) indicated little strong adsorption of ascorbic acid. Finally, hydrogen peroxide removes the adsorbed technetium from the column as pertechnetate, and it is difficult to see how peroxide would release pertechnetate from either a precipitated oxide or an adsorbed complex. Air also converts the adsorbed technetium to pertechnetate but at a much slower rate. We agree with Dr. Hupf that the chelate yield does not seem to be affected by air, but it does seem clear from the citrate data in Table 3 of our paper that the adsorbed species is not stable to air for the reasons given in the last paragraph on page 599.

3. The Redox potential data: The experiments in Table 2 of our paper involving the chelating agents DTPA and o-phenanthroline are identical except for the change in reduction potential of the iron. If a pertechnetate complex is being formed it should be formed in both cases because ferrous ion and pertechnetate concentrations and conditions are identical. However, if reduction is necessary, the iron-DTPA potential is sufficiently strong to reduce the technetium, but the iron o-phenanthroline potential is not. As the results show, only the DTPA system yields technetium-chelate. A control experiment in Table 4 of our paper shows that o-phenanthroline can form a chelate with technetium if a strong reducing agent is present.

We conclude from these three types of experiments that technetium is not present as pertechnetate. If the technetium is not bound to zirconium, it

seems logical for it to be present as a cation to form a chelate, as is the case with other transition metals. This is also in agreement with recent carrier ^{99m}Tc electrophoresis data.

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A SIMPLER METHOD FOR OPTIMIZING THE WINDOW OF THE ANGER CAMERA FOR ^{99m}Tc

The procedure for optimizing the window of an Anger camera for ^{99m}Tc proposed by Sanders et al (*J Nucl Med* 12: 703-706, 1971) does indeed provide a significant improvement in scan quality, as shown in their paper, but the method has two disadvantages. First, the use of a small ^{99m}Tc source

to determine the counting rate response over the range of "isotope peak" settings in effect produces a response curve for only a few of the 19 photomultiplier tubes in the array. Second, obtaining the counting rate over the full range of the "isotope peak" potentiometer may take several minutes.

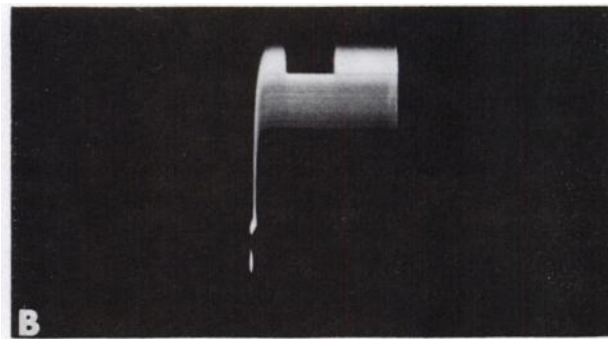
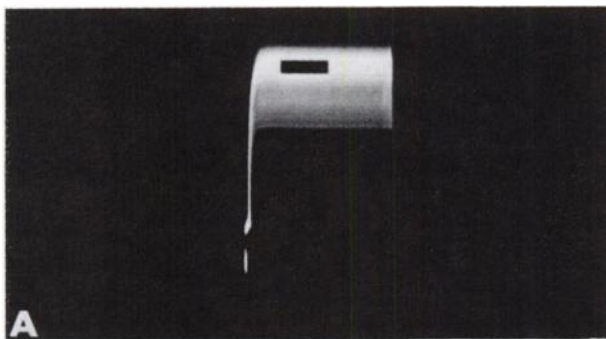


FIG. 1. In A 10% window is centered on photopeak of 140-keV gamma ray of ^{99m}Tc . In B, without any other adjustments, win-

dow width is increased to 25%. Window now covers energy range of 133-167 keV.

I have modified the technique of optimizing the window to overcome both of these problems. First, the method is used only with an extended source of ^{99m}Tc which may be a flood source or a patient who has received millicurie amounts of ^{99m}Tc for diagnostic examination. Second, by setting the window at 10%, the isotope peak dial is turned until the ^{99m}Tc photopeak is centered in the window as shown in Fig. 1A. Then without further adjustment the window width is increased to 25%. The effect on the photopeak window is shown in Fig. 1B.

The method is simple and while not exactly as accurate as the technique described by Sanders et al, we have observed the same marked improvement in scintiphotos obtained by using this optimized window.

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FEASIBILITY OF ^{133m}Ba AS A BONE SCANNING AGENT

Parenterally administered barium salts are largely bone seekers, and ^{131}Ba and ^{135m}Ba have been used as bone scanning agents (1,2). Both ^{131}Ba and ^{135m}Ba suffer from being produced from expensive, isotopically enriched stable targets. Another barium radionuclide, ^{133m}Ba , also has desirable properties as a scanning agent. In addition to reactor production

from ^{132}Ba by the n,γ reaction, it can also be made by the $^{133}\text{Cs}(p,n)$ reaction in a cyclotron (3).

Barium-133m decays ($T_{1/2} = 38.9$ hr) by emission of a 276-keV gamma ray to ^{133}Ba which is itself radioactive ($T_{1/2} = 7.2$ years). Although associated with all of the disintegrations of ^{133m}Ba , the 276-keV gamma ray is highly internally converted so that a