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Mind the buffering capacity of citric acid

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Mind the buffering capacity of citric acid

Abstract

Many microbial cultures are buffered with citric acid over a pH range of 2.5 to 7.0 since the pKa values for this triprotic acid are 3.13, 4.76 and 6.40, as shown in The Merck Index (pp 330-331, 10th Edition, Martha Windholz, ed.). However, the information about the buffering range of this weak acid is controversial since the pKa3 value may be 5.40, as specified in Day and Underwood (Quantitative Analysis, 6th Edition, 1991, p. 662. New Jersey: Prentice Hall). With this in mind, we determined the pKa values of citric acid at concentrations ranging from 5 mM to 50 mM, concentrations which are the most employed in buffers for the culture of many microorganisms.

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Many microbial cultures are buffered with citric acid over a pH range of 2.5 to 7.0 since the pKa values for this triprotic acid are 3.13, 4.76 and 6.40, as shown in The Merck Index (pp 330-331, 10th Edition, Martha Windholz, ed.). However, the information about the buffering range of this weak acid is controversial since the pKa3 value may be 5.40, as specified in Day and Underwood (Quantitative Analysis, 6th Edition, 1991, p. 662. New Jersey: Prentice Hall). With this in mind, we determined the pKa values of citric acid at concentrations ranging from 5 mM to 50 mM, concentrations which are the most employed in buffers for the culture of many microorganisms.

The experimental values obtained were 3.10, 4.80 and 5.40 for pKa1, pKa2 and pKa3, respectively (Figure 1A). Furthermore, citric acid does not seem to be a good buffer even considering pKa values ranging from 3.1 to 5.4 (Fig. 1A). This is because the values of the three dissociation constants are too close to permit distinction of the three proton receptor phases. The titration curve for sodium citrate with HCl (Figure 1B) confirmed the observation that citric acid has no buffering capacity at pH higher than 6.2. Figure 1A also shows the titration curve of 20 mM 2-[N- Morpholino]ethanesulfonic acid (MES) with 100 mM sodium hydroxide, clearly confirming its buffering capacity at pH 6.1, which corresponds to its pKa value.

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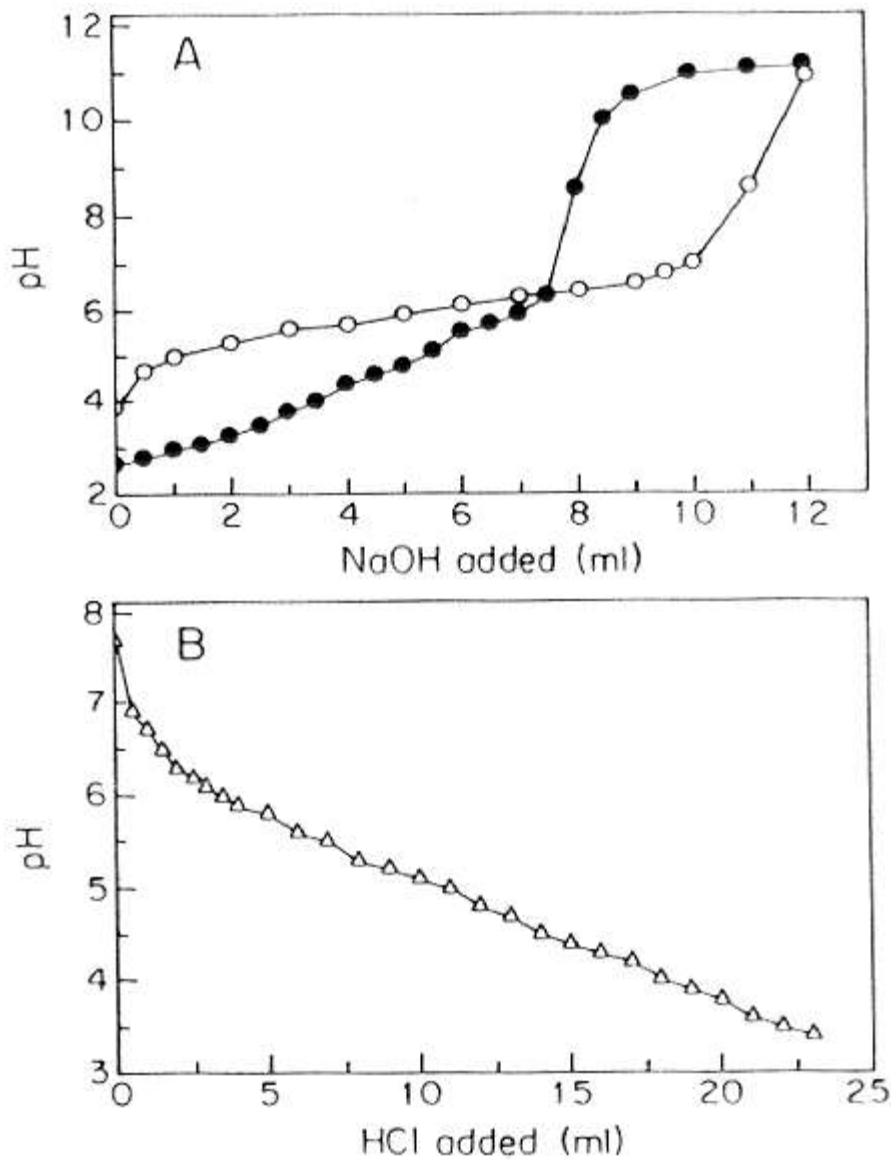


Figure 1. (A) Titration curves of 5 mM citric acid (50 ml) with 100 mM NaOH (p) and 20 mM MES (50 ml) with 100 mM NaOH (p). (B) Titration curve of 20 mM sodium citrate (50 ml) with 100 mM HCl. All determinations were made at room temperature and the pH was measured with a Mettler Herisau E-510 pH meter.