

KINETICS OF A TRANSIENT IODINE DISINFECTING SYSTEM FOR HYDROPHILIC CONTACT LENSES

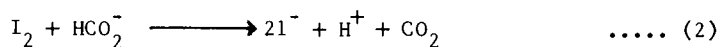
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1. Introduction

Povidone iodine is a complex between molecular iodine and polyvinyl pyrrolidone which possesses several advantages over molecular iodine including: greater stability, similar antimicrobial activity, much lower volatility, lower toxicity, and greater water solubility. Iodine is an oxidising agent and may be reduced to iodide by many species, one of which is formate ion. Povidone iodine reacts in a similar way with formate, and a study of this reaction is presented.

2. Study of the Reaction Between Sodium Formate and Povidone Iodine in Dilute Aqueous Solution

When sodium formate concentration is varied in the range 0.1% w/v - 1.0% w/v the rate of decomposition of iodine is directly proportional to the sodium formate concentration. In the range of $15 \mu\text{g}/\text{cm}^3$ - $100 \mu\text{g}/\text{cm}^3$ of available iodine (0.015 - 0.10% w/v povidone iodine), the overall reaction rate is inversely proportional to the initial available iodine concentration. For any initial level of available iodine the reaction appears to be first order with respect to available iodine for a considerable part of the reaction. There is no significant change in reaction rate in the pH range 3.0 - 9.0. There is a strong temperature dependence for the reaction studied and an Arrhenius plot produces a straight line, giving an activation energy of ~ 30.5 k cal/mole. The rate of decomposition of iodine is inversely proportional to iodide ion concentration. The mechanism of the reaction can be explained according to the following equations which represent a two stage process, i.e. first the generation of iodine (equation 1) followed by the reaction (equation 2) between iodine and sodium formate, giving iodide, carbon dioxide, and hydrogen ions:



3. Development of Disinfecting System

Taking into account the kinetic data for the povidone iodine/sodium formate system, a disinfecting system has been designed such that after ~ 45 min at 20°C all the iodine initially present has been converted to iodide ion.

Initial experimental work with various iodine concentrations showed that a constant level of $15 \mu\text{g}/\text{cm}^3$ iodine killed a 10^6 organism/ cm^3 challenge of test organisms (Staphylococcus aureus (NCTC 6571), Pseudomonas aeruginosa (NCTC 6750), Escherichia coli (NCTC 86) and Candida albicans (No.3153 London School of Tropical Medicine)) within 15 minutes. Consideration of reaction kinetics led to the selection of an initial concentration of $50 \mu\text{g}/\text{cm}^3$ available iodine which would exceed the minimum microbiological criterion for the disinfecting system.

One possible application of the system has been the disinfection of prosthetic hydrogels, particularly hydrophilic contact lenses. Poly-(2-hydroxyethyl methacrylate) hydrogel (polyHEMA) was selected for uptake/release studies with povidone iodine. Iodine which entered the polymer matrix was removed by the sodium formate solution. The system is effective between 15°C and 30°C for the concentration of iodine chosen ($50 \mu\text{g}/\text{cm}^3$) and for 0.5% sodium formate.

The complete system, disinfectant and neutralising agent can be combined in tablet or powder form, suitable for addition to purified water. Alternatively the povidone iodine can be presented in tablet form suitable for addition to preserved sodium formate solution. The resultant solutions after neutralisation are at neutral pH and isotonic.