

ELECTRIC CURRENT DENSITY IMAGING OF TABLET DISSOLUTION

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Abstract: The Electric current density imaging technique (CDI) was used to monitor the dissolution of and ion migration from tablets of different acids in agar-agar gel. Conventional MRI cannot monitor these processes, since it can only show changes in the size of the tablet during the dissolving process. CDI traces the dissolved ions thanks to changes in conductivity.

Key Words: Magnetic Resonance Imaging (MRI), Electric Current Density Imaging (CDI), Dissolution Process, Ion Migration.

INTRODUCTION

Electric current density imaging (CDI) is a magnetic resonance imaging (MRI) technique that images induced current density and conductivity distribution within any sample containing water with mobile ions [1, 2]. In this study, CDI was used to image the spatial variation of ionic concentration during the dissolution of an acid tablet [3]. The tablet reacted with the surrounding gel in an acid reaction $\text{COOH} \rightarrow \text{COO}^- + \text{H}^+$, the results of which were released mobile ions. For different acids, diffusion constants were determined by applying the diffusion equation to experimental data.

MATERIALS AND METHODS

CDI experiments were performed on the 100 MHz Bruker Biospec system equipped with micro-imaging accessories. Experiments were carried out in a Perspex cell filled with 1% agar-agar gel. The cell contained two concentric cylinders. The inner cylinder, with a diameter of 10 mm and a length of 12 mm, had electrodes at both ends, so that the electric current was flowing along the cylinder axis. The electrodes were connected to an amplifier with a 220 V output voltage. The outer cylinder (16 mm diameter) was used as a reference, and was also filled with 1% agar-agar gel, but had no current flowing through it. A cylindrical acid tablet, with a diameter $2r$ of 3 mm and a height h of 12 mm, was placed in the center of the inner cylinder. The dissolution and ion migration processes were monitored by CDI at time intervals of 4 minutes until the tablet had completely dissolved and the current density was uniform throughout the inner cylinder. The experiment was performed for citric, oxalic, and tartaric acids.

RESULTS AND DISCUSSION

Once the acid tablet was inserted into the 1% agar-agar gel, positive and negative ions started to form and migrate away from the tablet. The concentration of mobile ions changes the gel conductivity and therefore affects the CDI images. Current density images thus showed the progression of tablet dissolution and ion migration (Fig. 1, second column), while no difference (except for changes in the size of the tablet) was observed on conventional MRI images (Fig. 1, first column). The diffusion coefficients were determined from the average signal intensity of the CD-images acquired at different times after the beginning of the dissolution process (Fig. 1, third column).

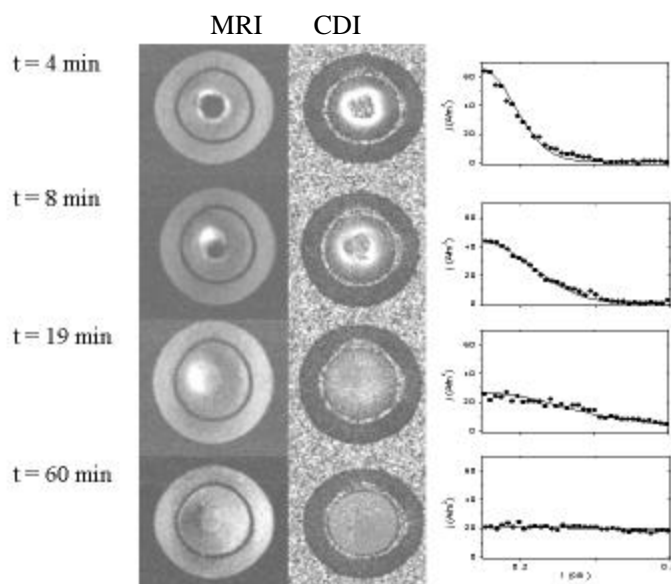


Fig. 1. Conventional MRI (first column) and CDI (second column) of tartaric acid tablet dissolution in 1% agar-agar gel at different times. The outer cylinder was used as a reference (no electric current flowed through it). The intensity of the CDI, which is proportional to the electric current density (black: no current, white: maximum current), represents the concentration of positive and negative ions. An average CDI intensity (third column) is given as a function of the distance from the initial edge of the tablet (circles: measurements, line: theory).

The measured average diffusion coefficients D_M were compared with the diffusion coefficients from the literature D_L . For tartaric acid: $D_M = 0.7 \pm 0.2 \times 10^{-5} \text{ cm}^2/\text{s}$, $D_L = 0.8 \times 10^{-5} \text{ cm}^2/\text{s}$, for citric acid: $D_M = 0.6 \pm 0.2 \times 10^{-5} \text{ cm}^2/\text{s}$, $D_L = 0.7 \times 10^{-5} \text{ cm}^2/\text{s}$, and for oxalic acid: $D_M = 1.3 \pm 0.2 \times 10^{-5} \text{ cm}^2/\text{s}$, $D_L = 1.1 \times 10^{-5} \text{ cm}^2/\text{s}$. Employing a simple model of acid tablet dissolution, it is shown that

the CDI method monitors ion diffusion in a gel on the basis of conductivity changes. The potential use of this technique in monitoring the free diffusion of substances through liquids, solids and membranes, and thus in monitoring the dissolution and distribution of drugs in tissue is considerable.

REFERENCES

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