Release of iodine from wood in finite volumes of water in succession

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Summary Iodine in water is of great interest in some undeveloped countries, and wood can be used as a iodine reservoir capable of releasing it with a controlled rate. The problem of iodine release from a wooden beam is considered in this paper in a rather complex case. The beam is immersed in a finite volume of pure water for a given time, and then reimmersed successively in the same way. Equilibrium of desorption is not attained at the end of each stage of immersion. A numerical model with finite differences was built and successfully tested, providing the kinetics of release and the profiles of iodine concentration in the wood.

Introduction
Wood being an hygroscopic material, pieces of wood exchange moisture or water with the surrounding atmosphere, depending on the conditions. Moreover wood is anisotropic with three principal axes of diffusion and three principal diffusivities, the longitudinal diffusivity being more than ten times larger than the radial and tangential diffusivities which are about equal (Siau 1971). While the principal diffusivities are concentration-dependent in the case of moisture transport below the fibre saturation point (FSP) (Bramhall 1976; Moschler and Martin 1968; Droin et al. 1988), they can be considered, about constant when the moisture content is beyond the FSP. This is the case when the wood is immersed in water (El Kouali et al. 1992; Mounji et al. 1991).

Water transport through wood may be either a drawback or an advantage. It is a drawback when water condensation occurs on the surface of the wood (Mounji and Vergnaud 1992), leading to moisture content values beyond the FSP which are responsible for fungi attacks (Dirol 1985). This transport also provokes a release of the chemicals previously introduced in the wood for its protection, when the wood is immersed in water. On the other hand, advantage may be taken of this water transport for controlling the release in water of iodine or other materials. Polymers were previously used with success for controlling the release of chemicals in water, and applications were found in agriculture (David et al. 1988; Vergnaud 1991).

As the problem of releasing iodine in water at a controlled rate arises in undeveloped countries where people suffer from goitrous diseases, some attempts were made using devices consisting of silicone. As devices made of silicone are rather complex and costly, wood can be used for controlling the rate of iodine release in water.
The first purpose in this paper was to show that a controlled release of iodine in water can be obtained by immersing in water a wood beam previously saturated with iodine. There are several methods: First, by immersing the wood specimen either in a very large volume of stirred water or even in running water. Second, by immersing the wood specimen in a finite volume of water for a long time until equilibrium has been reached. Third using a finite volume of water, but the time of immersion being too short for equilibrium of desorption to be attained.

The second objective of this study was to build a numerical model with finite differences able to describe the release process. The process of release in water is as follows: water enters the wood, dissolves iodine, enabling iodine to diffuse in the water located within the wood. However, a simplified model was used, taking into account only the diffusion of iodine out of the wood. Some emphasis was placed upon the boundary conditions, as wood was immersed in a finite volume of water for a period of time at which equilibrium was not reached, and then successively reimmersed in another finite volume of water. This case is the more complex of the above mentioned three cases: In the first case, all iodine is extracted from the wood; in the second, uniform concentration is obtained at the end of each immersion corresponding to equilibrium; in the third case, as equilibrium was not reached at the end of each stage of absorption, a concentration profile through the wood was obtained. Moreover, after each stage of immersion in water, the wood was left to dry in the surrounding air (Vergnaud 1992).

Theoretical

Assumptions

The following assumptions were made, during the stages of the process: absorption of methanol solution of iodine; evaporation of methanol; release of iodine in water.

i) The wood specimens are cut in such a way that their sides are parallel with the three principal axes. The length of the parallelepiped (4 cm) is along the longitudinal axis.

Stage of absorption of methanol with iodine.

ii) Methanol and iodine are transferred within the wood by transient diffusion up to equilibrium. The concentration of iodine is thus uniform at the end of this stage of absorption.

iii) This pseudo-equilibrium is reached after 150 min of absorption for cubic specimens and 360 min for the parallelepipedic wood.

Stage of evaporation of methanol.

iv) The process of drying is controlled by diffusion of methanol within the wood and evaporation from the surface. Iodine does not evaporate.

v) At the end of the process of evaporation, the concentration of iodine within the wood is uniform.

Stage of release of iodine in water in a multi-step process.

vi) The release of iodine in water is controlled by tri-dimensional diffusion, with a finite coefficient of matter transfer on the surface.

vii) As the volume of water (200 ml) is finite at each step, the iodine concentration in water increases during the stage of release.

viii) At the end of the first step of release in water, the sample is dried. An assumption was made, whereby the concentration distribution of iodine in the wood is uniform at the end of the drying step.

ix) At the end of the drying step, another assumption was made, in which the concentration distribution is assumed to be the same as that obtained at the end of the previous step of immersion in water.

Both assumptions made in (viii) and (ix) were tested by comparing the kinetics obtained by experiments and calculation with the help of the model.