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Dynamic surface tension of xylem sap at the air-water interface

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The surface tension (ST) of xylem sap at the water-air interface is a crucial phenomenon, influencing many physiological events such as air seeding and embolism, by which xylem vessels become air-filled and cease to function. Refilling of embolized, may relies on sap's surface activity at the interface. It is commonly assumed that the ST of xylem sap is equal to the ST of pure water (72 mN/m). However, xylem sap is a complex solution and consists of surface-active molecules that may adsorb and accumulate at the water-air interface and thereby reduce the ST of water as a function of their aqueous concentration. However, when a new water-air interface is formed, equilibrium ST is not reached instantaneously. Specifically, amphiphilic molecules are kinetically adsorbed and undergo orientation at the interface following diffusion from the bulk solution. Dynamic ST of xylem sap and liquid-solid interactions, describing the surface phenomena of the xylem of vascular plants is currently not fully understood. This is mainly due to a lack of quantitative knowledge on the rate and extent of dynamic and equilibrium ST of sap. In this regard, the main objective of this study is to quantify the dynamic and equilibrium ST of xylem sap as a function of their aqueous concentration. We extracted xylem sap from lemon trees and measured ST as a function of time using the pendant drop technique. The dynamic ST data were analyzed using empirical and diffusion-control mathematical models which adequately described the exponential-like decay of the ST as a function of time. The results showed reduced ST of water in the xylem sap, indicating significant surface activity, reaching equilibrium ST values as low as 42 mN/m. The rate of ST decay was higher in high sap concentration and reduced in diluted one. The results of dynamic and equilibrium ST and the corresponding model will be presented and their implications for xylem hydraulic functioning will be discussed.

Keywords: Dynamic surface tension, Equilibrium surface tension, Diffusion, Xylem sap.