# Conifers as green renewable inhibitors for steel acid cleaning

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While traditional corrosion inhibitors are quite effective at protecting metal, they also pollute the environment. Since conifers are renewable plants, there has been a lot of interest in using plant extracts as green corrosion inhibitors [1,2]. They fit industry standards and make excellent raw materials for corrosion inhibitors. However, because of the high dosage and unclear composition of these corrosion inhibitors, they have not been successfully used in industry. In this work black pine (Pinus nigra, PN) and Pančić spruce essential oils were synthesized from fresh needles, which were further tested as a mixture of green organic substances that inhibit steel corrosion. In addition, the active substances of black pine essential oil (α-pinene, β-pinene, and caryophyllene) were tested under the same conditions and their effect on the corrosion rate was compared with the effect of black pine essential oil. The influence of phytochemicals (bornyl-acetate, borneol, and camphene) on the effectiveness of the essential oil of Pančić's spruce, as well as on the adsorption on steel, was evaluated by theoretical and surface methods. Through experiments and theoretical calculation, the corrosion inhibition effect of these inhibitors on steel was studied in 1 M HCl solution at 25 °C. The optimal inhibitor concentration as well as the time of immersion were assessed by Electrochemical impedance spectroscopy.
It has been demonstrated that all inhibitors become more effective over time. At the same concentration of 80 ppm, the most prevalent component of the PN essential oil, α-pinene, demonstrated a poorer corrosion prevention efficacy than β-caryophyllene, that reached 96% inhibition efficiency. Both PN and Pančić essential oil were mixed types inhibitors with prevalent influence on the inhibition of the cathodic reaction, as shown by polarization measurements. SEM and XPS analysis confirmed the presence of borneol and bornyl-acetate, along with non-soluble oxides that formed a protective film on metal surface. Binding mechanism of the Pančić essential oil inhibitor molecules was resolved with the analysis of the projected density of states [3]. The theoretical calculations [4] indicated that some of the phytochemicals in Pančić essential oil bond to the steel by chemisorption (bornyl-acetate and borneol) while others by physisorption (camphene). This has also been confirmed by values of adsorption free energy determined from Langmuir Isotherm.

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References

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