Human & Veterinary Medicine
International Journal of the Bioflux Society HVM

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Research Article

The adsorption behaviour of buffered aspirin monitored by Raman and surface-enhanced Raman spectroscopy

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Abstract. Buffered aspirin tablets have been Raman investigated and further used for surface enhanced Raman scattering on Ag colloidal nanoparticles. The pH dependence SERS spectra revealed that strongly interact with the nanoparticles and result in different orientation with respect to the metal surface. The drug was detectable at micromolecule concentrations. Different adsorption behaviors of these molecular species are discussed.

Key Words: Aspirin, Raman, SERS.

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Introduction

Aspirin is a non-narcotic analgesic and this drug is indicate for the treatment of mild to moderate pain, as an anti-inflammatory agent for the treatment of soft tissue and joint inflammation. The chemical structure of aspirin (C9H8O4) is shown in the figure 1.

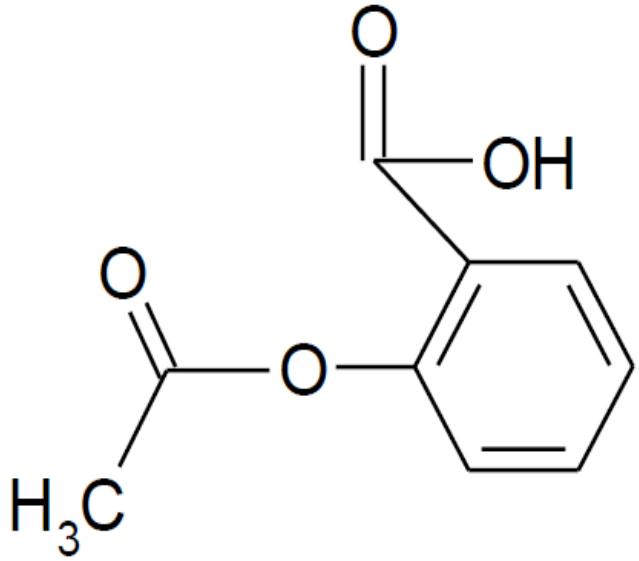

Figure 1. Molecular structure of aspirin ($C_9H_8O_4$)

The aspirin appears as white crystals or white crystalline powder or granules.

Aspirin as it self is very slightly soluble in the acidic conditions of stomach and has the tendency to form deposit in stomach and as result irritates considerably the stomach. The buffered aspirin it is more easyly solubilized in the acidic media from stomach.

A number of epidemiological studies have reported an inverse association between the use of non-steroidal anti-inflammatory drugs (NSAIDs) including aspirin, and/or a history of arthritis, and cognitive impairment, and AD/dementia (Jenkinson et al 1989; Doraiswamy et al 1996; McGeer et al 1996; Stewart et al 1997; Gideon et al 2004; Anthony et al 2000; in t'Veld et al 2001). Experimental studies have also proposed the possibility of protection from NSAIDs by decreasing the ß-amyloid production and accumulation stimulated by cytokines (McGeer et al 1994; Aisen & Davis 1994; Thomas et al 2001).

The combination of a narcotic and aspirin increases pain relief better than either medication used by it. Because, narcotic analgesics act on the central nervos system to relieve pain and when this are user for a long period of time, is possible they cause mental and physical dependence with drawal symptoms when the medication is stopped abruptly (Barkin et al 2001). Aspirin is not habit forming but does have some unwanted side effects if used in higher doses or for long periods of time (liver damage). These medications are used in the relief of pain such as after surgery, after an injury, and for some types of headaches.

Because the subject analgesics are controversial and the biochemistry is very complex, the aim of this study is monitoring of buffered aspirin and its adsorption behavior by RAMAN and SERS spectroscopy.

The commercially available tablets could be accurate identified and monitored even through the blister pack. SERS technique has proven a reliable method for monitoring and identification of the drug, even in the presence of the excipients, at very low concentrations, showing great promise for on-line monitoring at physiological concentration level.

In the present work, based on the vibrational Raman characterization of buffered aspirin tablets, we tried to distinguish the various molecular species mode in terms of pH value, the adsorption manner to the silver colloidal nanoparticles, to establish the functional groups involved in adsorption and to check the possibility to monitor low dosage level using SERS spectroscopy.

Experimental

Pharmaceutical tablets of buffered aspirin commercially available (Europharm), were employed in our study without further purification. The aspirin solutions were obtained dissolving one tablet aspirin in 10 mL distillated water; at room temperature.
The SERS samples were obtained by adding 0.01 mL of aspirin solution of 10^{-5} mol L^{-1} to 3,5 mL of silver colloid, getting the final SERS concentration at 8 µmol L^{-1} for and buffered aspirin.
The SERS spectra were obtained at different pH values using a sodium citrate silver colloid, prepared according to the literature (Lee & Meisel 1982). The pH adjustment was accomplished with 10^{-1} mol l^{-1} HCl solution for the acid values and with 10^{-1} mol L^{-1} NaOH solution for basic values).
The micro-Raman and the SERS spectra of the aspirin on silver colloid were recorded with a Dilor Raman micro spectrometer (Horiba-Jobin-Yvon, model LabRam) using the 514.5 nm excitation line from an argon ion laser (Spectra Physics, model 2016). The spectra were collected in the backscattering geometry using a microscope equipped with an Olympus LMPlanFL 50x objective with a spectral resolution of 2 cm^{-1}.
The detection of Raman signal was carried out with a Peltier-cooled CCD camera and for the signal acquisition was employed the analyzing software package LabSpec. The laser power varied from 150 to 200mw.

Results and discussion

The vibrational fundamentals from the micro-Raman spectrum, (Figure 2) were analyzed and assigned according to the available literature (Wang et al 2003; Peica et al 2004). The decrease in relative intensity of Raman signal in the micro-Raman spectrum of buffered aspirin may have a medical explication.
Peica et al (2004) have measured the SERS spectra of aspirin tablet on an aqueous silver colloid.
The aspirin tablet contains also inactive types of substances in addition to acetylsalicylic acid active ingredient. Inactive substances may diminish the gastrointestinal acidity (of the human body) and improve the tolerance for large dosage. The starch ingredient is known to dissolve readily in water and to help the tablet disperse once swallowed. Small amounts of lubricants (e.g., stearic acid) are usually added as well. These lubricants help the tablets, once pressed, to be more easily ejected out of the matrix.
Peica et al (2004) recorded the ordinary Raman spectra of aspirin using the 514.5 nm excitation line and noticed that some additional bands appeared in the spectrum of aspirin. However, the Raman signal characteristic to the active ingredient in buffered aspirin could be easily recognized.
Furthermore, the fast, non-invasive nature of the Raman technique allowed for the molecular probing of the tablet ingredients at various depths whilst still in plastic packs.

Comparing the SERS spectra of buffered aspirin (Figure 2b) with the Raman spectra of aspirin solution significantly increase in Raman intensity of the SERS spectra is observed. This indicates chemisorptions of the molecule on colloidal particles of silver surface.
Analysing the SERS spectra of buffered aspirin (Figure 2b), we can observe the very strong symmetrical stretching vibrational mode of C=O, and in plane bending mode of hydroxyl, the both belongs to the carboxyl group (1614 cm^{-1}).

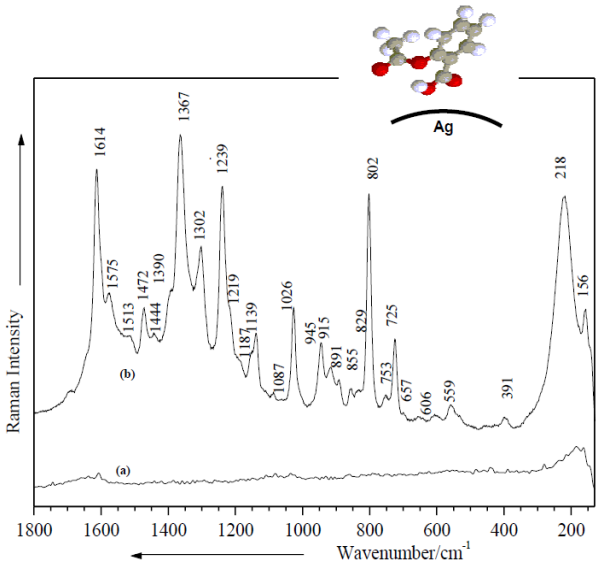

Figure 2. Micro-Raman spectrums of buffered aspirin solution (a) and the corresponding SERS spectrum (b) (Excitation 514.5 nm, 150 mW).

This suggests that the aspirin molecule is chemisorbed on the silver surface through the oxygen simple bonded to the ester group, in a tilted orientation. That is further confirms by the Ag-O stretching mode at 218, and 156 cm^{-1}.
The pH dependence SERS spectra of aspirin aqueous solutions in the basic and acidic pH range are presented in Figure 3, and 4 respectively.
The SERS spectra of buffered aspirin at different acidic pH values (Figure 3), suggest the major changes in the molecular identity. The decrease in relative intensities of symmetrical stretching mode of C=O belongs to the carboxyl group (1645 cm^{-1}), the C-OH deformation mode (1377 cm^{-1}), the asymmetrical stretching mode of CC to the ring (1312 cm^{-1}), and the scissoring of the carboxyl group (802 cm^{-1}), which become very weak or disappear.
The new appear peaks for in plane O-C=O symmetrical bending mode (644 cm^{-1}), and the decrease in relative intensities of CC, and CH bending modes, come to suggest the protonated form of buffered aspirin.
The very weak signal at acidic pH values can propose the protective activity of this caned of aspirin.
On going from acidic to basic pH values we can observe the nonprotonated form of buffered aspirin (Figure 4). More changes appear at peaks corresponding to the in plane CH3 bending modes (1399, 1342 cm^{-1}), C-OH stretching mode (1365 cm^{-1}).

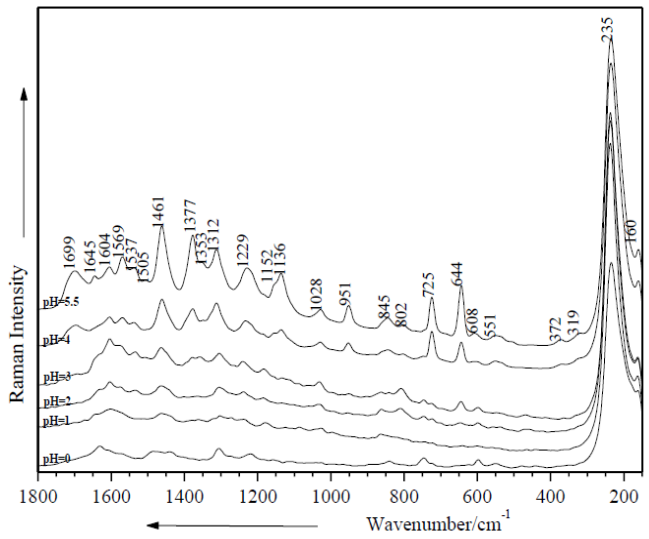

Figure 3. SERS spectra of buffered aspirin at different acid pH values (Excitation 514.5 nm, 200 mW).

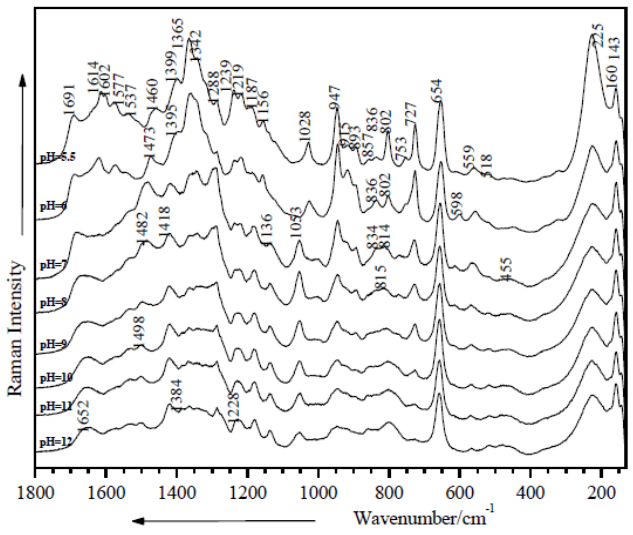

Figure 4. SERS spectra of buffered aspirin at different basic pH values (Excitation 514.5 nm, 200 mW).

Therefore the band correspondents to the symmetrical in plane OH bending mode (947 cm-1), the out of plane CH bending mode (727 cm^{-1}), and symmetrical in plane O-C=O bending mode (654 cm^{-1}) decreases in relative intensities.

Conclusion

Raman spectra of aspirin tablets have been recorded and the significant bands of characteristics functional groups were indentified. The Raman signal is very strong for the buffered aspirin, which can suggest the protective activity for the gastrointestinal mucous membrane. SERS spectra of aspirin could be recorded even at low concentrations with a conventional SERS setup (10^{-6} mol L^{-1}).

A change in the molecular identity, on going from basic to acidic pH values could be evidenced by analyzing the SERS spectra. The surface selection rules have reasonably explained the adsorbate structures on the metal surface at different concentrations and pH values.

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Citation	Andronie L, Miresan V, Raducu C, Pop I, Coroian A, Coroian CO. The adsorption behaviour of buffered aspirin monitored by Raman and surface-enhanced Raman spectroscopy. HVM Bioflux 2014;6(4):187-190.
Editor	Ştefan C. Vesa
Received	3 September 2014
Accepted	1 November 2014
Published Online	2 November 2014
Funding	None reported
Conflicts/ Competing Interests	None reported