International Journal of Chemical and Biological Sciences
www.chemicaljournal.org
Online ISSN: 2664-6773, Print ISSN: 2664-6765
Received: 02-04-2022, Accepted: 16-04-2022, Published: 30-04-2022
Volume 4, Issue 1, 2022, Page No. 29-33

Raman spectroscopy analysis for monitoring of chemical composition of aspirin after exposure to plasma flame

Jasim M S Jamur
Department of Chemistry, College of Education for Pure Science (Ibn Al- Haitham), University of Baghdad, Iraq

DOI: https://doi.org/10.33545/26646765.2022.v4.i1a.36

Abstract
Raman spectroscopy method was optimised to examine the chemical changes of the aspirin tablets after interaction with a helium temperature. Several aspirin tablets were exposure to plasma assisted desorption ionisation flame by different times (10, 30, 50, 60, 180 and 300 seconds) and then analysed by Raman spectroscopy using the optimal conditions. The changes in chemistry between exposed tablets and fresh tablet (without exposure to plasma) were compared. The vibration peaks of aspirin molecule in the Raman spectrum were identified by checking the peak position. The results showed clear spectra with increasing in intensity of vibration peaks until 30 seconds, whereas no spectra were measured for the exposed tablets to plasma flame after 50 seconds. It can therefore, assumed that the chemistry structure of aspirin compound might be damaged by exposing to high temperature.

Keywords: aspirin, monitoring, Raman spectroscopy

Introduction

Further details about the degradation structure of pharmaceutical products are required to improve the stability and determine the degradation products and impurities if have any toxicity [1–4]. Temperature is an important component in the climate system and plays a key role in a chemistry change of compounds. Some pharmaceutical compounds are being disadvantages or toxic chemicals due after exposure to the temperature [5]. Exposure to the temperature has been shown to be related to adverse effects in human health both directly and indirectly. Therefore, these rapid changes are having a serious effect on environmental and biological impacts of chemical compounds [6]. In the range of research areas such as pharmaceutical and environmental sciences, the analysis of small molecules has become important [7]. Different analytical techniques such as near infrared (NIR), Fourier transformed infrared (FTIR), nuclear magnetic resonance (NMR) and high performance liquid chromatography (HPLC) have been used to analyse the pharmaceutical solid compounds [8]. Recently investigators have examined the effects of temperature on the stability of pharmaceutical samples. The thermal stability of aspirin samples after treated with 40˚C and UV-12 h was studied by Al-Maydama *et al*. and found to be lower to that of the untreated samples using HPLC, photocatalytic, X-ray diffraction (XRD) and scanning electron microscopy (SEM) methods [9]. In the study by Acharya and co-wokers, IR, mass and ^{1}H NMR methods have been successfully applied for analysis of the thermal degradation product which was obtained from the interaction of aspirin and salicylic acid. This study confirmed that the structural on the new thermal product is different in comparison to those of aspirin and salicylic acid [10].

The chemical composition of artepillin C and *p*-coumaric acid was investigated using HPLC method after exposure to high temperature and it showed that the stability of these compounds were affected [11]. However, HPLC is expensive, long run time and consumes solvents. In the study by Johnsiani *et al*., several techniques such as NMR, quadruple time-of-flight mass spectrometry (Q-TOF/MS) and electrospray ionisation collision-induced dissociation tandem mass spectrometry (ESI-CID-MS/MS) have been used to study the degradation of sorafenib tosylate after exposure to different stress conditions including the temperature [12]. Vishnuvardhan and co-workers have shown there was significant degradation of silodosin drug under hydrolytic, oxidative and thermal conditions using LC-ESI-MS/MS method [13].

HPLC has also been applied using these stress conditions to study the behaviour degradation of sofosbuvir drug [14]. A positive degradation was also shown for racecadotril drug during temperature exposing using NMR, GC-MS, LC-MS/MS techniques [15]. Pulsed laser deposition has also been used to study the temperature effect on the chemical structure of copper oxide [16].

Aspirin tablet was used in this investigation as a model sample. In this work, the first part deals with the exposure of several aspirin tablets to plasma flame and the second part is identify the chemical composition of each sample using Raman spectroscopy.

The presented work amis to use Raman spectroscopy as a simple and suitable method for analysing the thermal stability of drugs during exposure to temperature.

Experimental

Apparatus

Plasma assisted desorption ionisation (PADI) was used as a source of plasma flame with helium gas. The PADI source including a pencil in the end of the plasma pencil. The visible plasma plume emerging from a coaxial helium gas flow 13.65 MHz RF. Plasma pen was near-contact (5 mm separation) with the sample under investigation, using a settings of 8 W and a carrier gas flow of 224 mL/min. Helium was used with electric discharge to produce electrons, ions and excited state gas. In addition to those, the energy of helium is higher than other gases such as nitrogen and this is enough to make ions and it can gives stable signals.

Raman spectroscopy (model Thermo DXR) was used with spectral range 3500-50 cm^{-1}. The Raman conditions such as laser wavelength, laser power, objective, collect exposure time, sample exposure and aperture were optimised and found to be: 532 nm, 10.0 mW, 10x, 4.0 sec, 2 and 50 µm pinhole respectively.

Chemicals

Aspirin tablets (containing 300 mg aspirin per tablet) were manufactured by Aspar Pharmaceuticals Ltd, UK and helium gas was supplied by British Oxygen Company gases, UK with purity 99%.

Preparation of samples

The samples of aspirin tablets were exposed to the PADI plasma for different times after which they were analysed directly by PADI-MS without pretreatment and the spectra were recorded as a function of time.

Procedure

Several samples of aspirin tablets were exposed to under atmospheric pressure during different times: 0, 10, 30, 50, 60, 180 and 300 seconds and then analysed directly by Raman spectroscopy using the optimal conditions with a total time of 1 minute. The temperature in the helium plasma reached to 70˚C during the analysis time of 60 seconds after which it decreased up to 300 seconds. Therefore, high temperature could be a major factor causing destroy the aspirin molecule.

Results and discussion

The samples of aspirin tablets after exposed to the plasma flame were analysed by Raman spectroscopy using the optimal conditions as outlined in Section 2.1. The signal intensity measurements of the exposed samples were compared to that of fresh sample (0-second). A chemical structure of aspirin is shown in Figure 1. In Figure 2, there is a clear signal intensity of vibrational peaks for 0-second plasma. The carbonyl group (C=O) has stretching vibration at 1600 cm^{-1}. The vibrations involve C-H and C-CH_3 were observed at 2950 cm^{-1} and 1300 cm^{-1} respectively. Other vibrations such as C-O-H, O-H and aromatic ring are shown in Table 1.

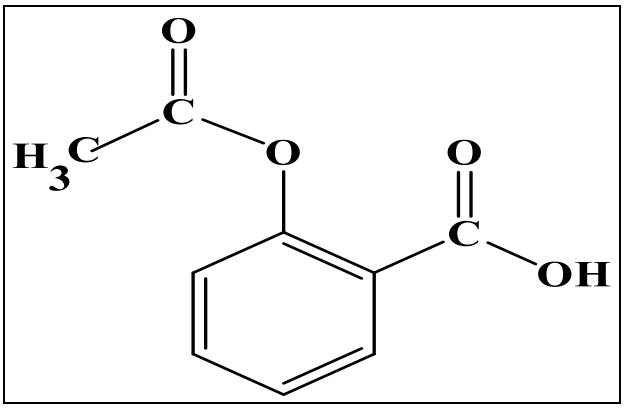

Fig 1: Chemical structure of aspirin.

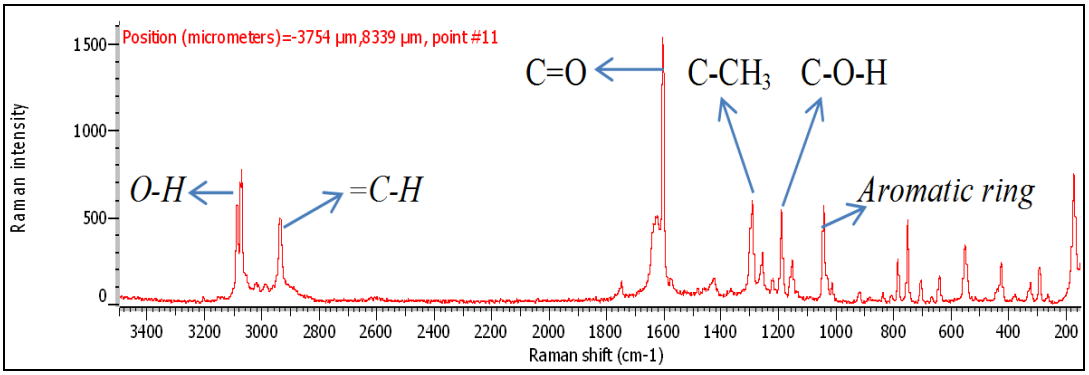

Fig 2: Raman spectrum of 300 mg fresh aspirin tablet (0-second).

Table 1: Raman identification of vibrations of aspirin

Peak position cm^{-1}	Vibration
1030	Aromatic rings
1200	C-O-H (OH substitution)
1300	C-CH3
1600	(C=O) Stretch
2950	=C-H
3050	O-H

In order to investigate the effect of plasma flame on aspirin chemistry, the intensity and position of vibration peaks were compared between exposed samples and 0-second tablet. The analysis results show the sex measures of different exposed times (0, 10, 30, 50, 60, 180 and 300 seconds). As shown in Table 2, the signal intensity of vibration peaks increased up to ~ 30 seconds, after which it decreased to 50 seconds. However, no peaks were detected at1 min, 3 min and 5 min. No important shift in the peak position was found for any vibration. The observed differences in intensities could be attributed to that the chemical structure of aspirin tablets was not affected by plasma flame until 30 seconds of exposure time, Figures 3 and 4, while it was affected and changed after this time.

On the other hand, the change in 50 seconds was lower compared to those of 60, 180 and 300 seconds, Figure 5, because Raman has been unable to measure the spectra of exposed tablets after 60 seconds. These results confirm there is no damage in the tablets until 30 seconds, after which a little was observed with 50 seconds, and then the damage increased from 60 to 300 seconds.

Table 2: Peak height of vibrations for fresh and exposed aspirin tablets.

Exposure times (seconds)	Aromatic rings	C-O-H (OH substitution)	C-CH3	(C=O) Stretch	=C-H	O-H
0	550	550	600	1600	550	800
10	1400	1500	1600	4000	1100	2300
30	2000	2500	3000	5500	1700	2600
50	750	500	500	1800	800	1400
60	__	__	__	__	__	__
180	__	__	__	__	__	__
300	__	__	__	__	__	__

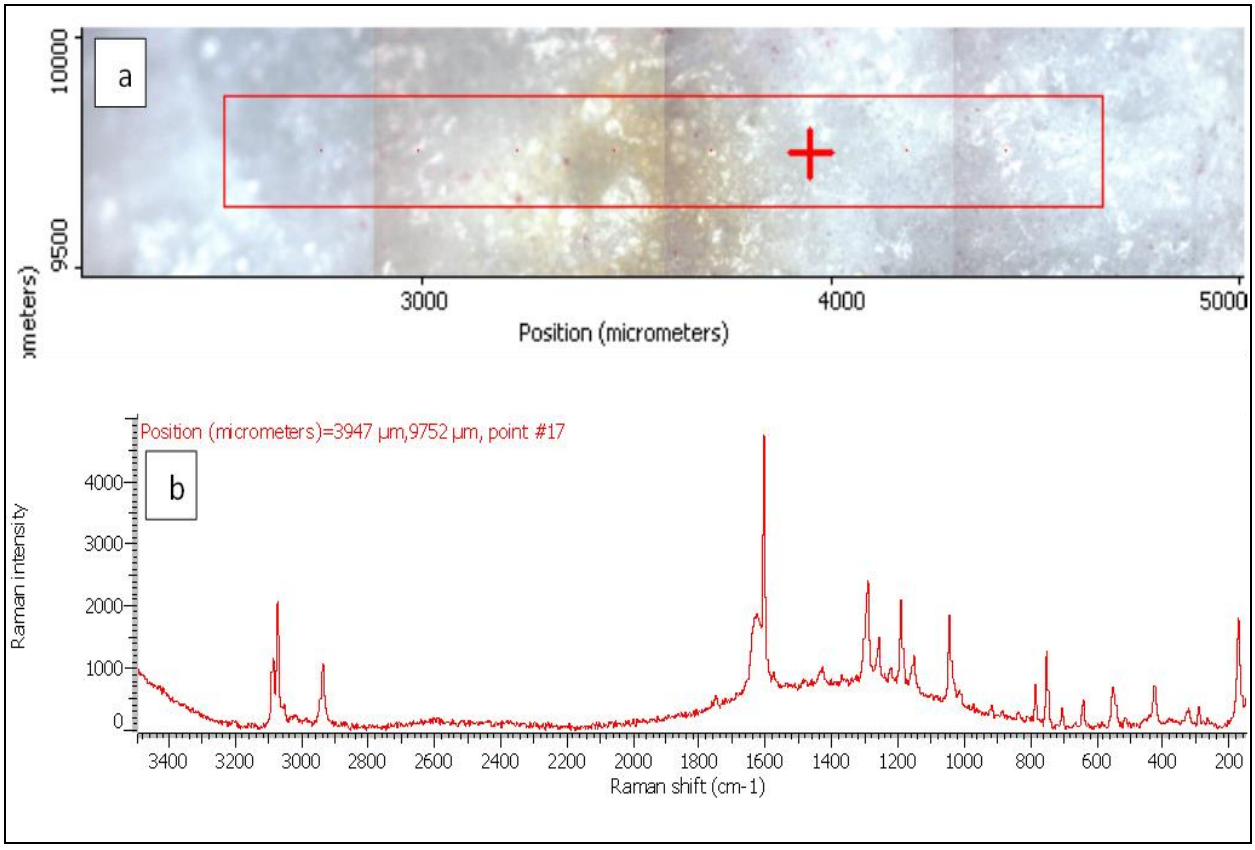

Fig 3: Raman photo surface (a) and Raman spectrum (b) for aspirin tablet after exposure to plasma flame at 10 seconds.

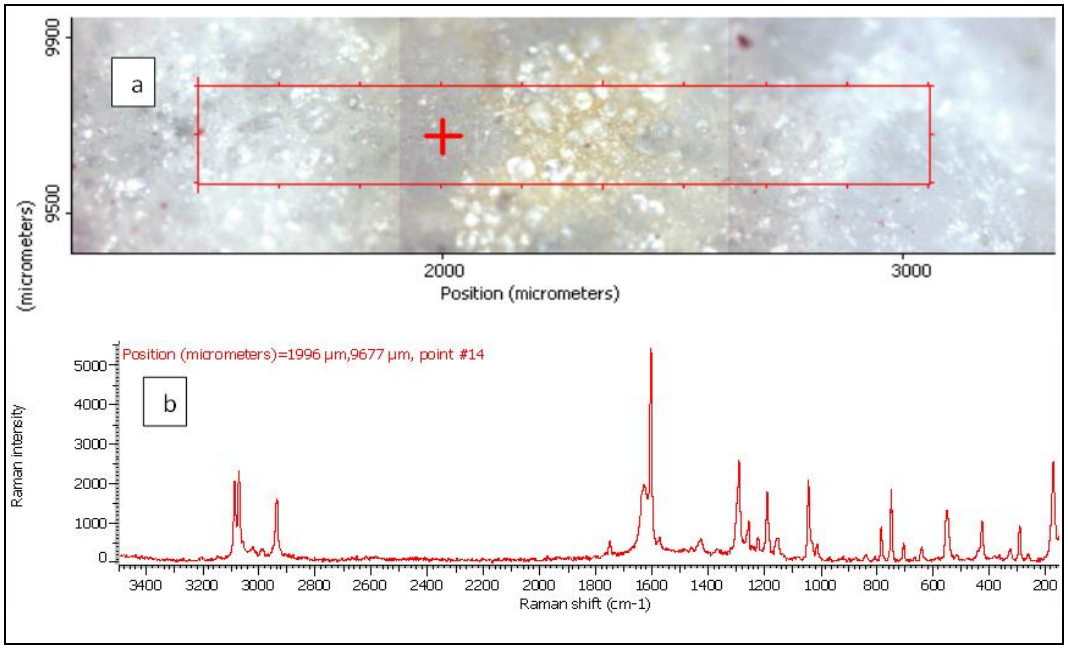

Fig 4: Raman photo surface (a), Raman imaging (b) and Raman spectrum (c) for aspirin tablet after exposure to plasma flame at 30 seconds.

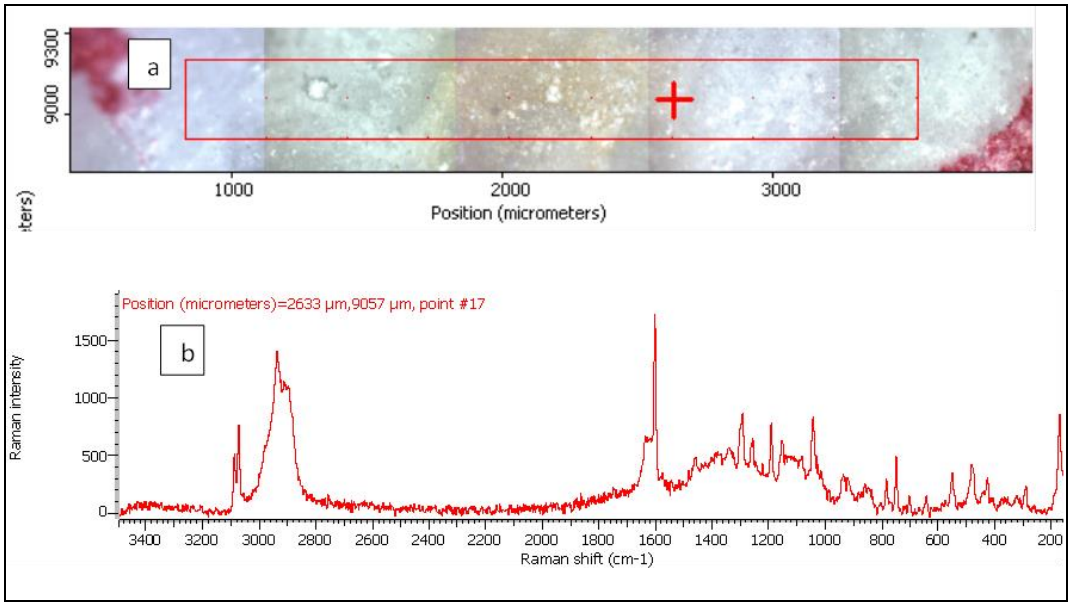

Fig 5: Raman photo surface (a) and Raman spectrum (b) for aspirin tablet after exposure to plasma flame at 50 seconds.

These results are in agreement with Al-Maydama *et al*. (9) findings which showed that the thermal stability and degradation of aspirin samples after exposure to temperature were changed in comparison to those of the untreated samples. In this previous study, the XRD method showed decreasing in peak intensities of treated aspirin samples and this might be attributed to the reduction in the crystal structural of the aspirin. In addition, SEM images showed that the surface morphology of the treated samples is changed and the reason for this is the crystal structural of the treated aspirin particles is lower regular shape than that of the untreated samples. Accordance with the present results, previous study (Acharya *et al.*) has demonstrated that aspirin suffers from degradation during the thermal reaction with salicylic acid.

Conclusions

In this investigation, the aim was to show whether the thermal stability of aspirin can be affected by interaction with temperature helium. The temperature was chosen of such conditions for the impact on aspirin tablets to ensure the quality and safety of pharmaceuticals. This study has shown that the stability of aspirin was changed by exposing to plasma flame for a long time (≥ 1min). However, the results has confirmed that the spectra did not show any shift for the vibration peaks. The results have significant implications for the understanding of how the temperature may have affected the chemistry of pharmaceutical tablets. Although the current study is based on a small sample, the findings suggest the study should be repeated using different forms of samples. Further

research could also be conducted for the investigation by using other methods of analysis such as infrared (IR) and mass spectrometry.

References

1. Purna Chander C, Raju B, Ramesh M, Shankar G, Srinivas R. Liquid chromatography/electrospray ionization tandem mass spectrometry study of repaglinide and its forced degradation products. Rapid Communications in Mass Spectrometry,2018:32(15):1181-90.
2. Borkar RM, Raju B, Srinivas R, Patel P, Shetty SK. Identification and characterization of stressed degradation products of metoprolol using LC/Q-TOF-ESI-MS/MS and MSn experiments. Biomedical Chromatography,2012:26(6):720-36.
3. Chander CP, Raju B, Sulthana A, Srinivas R. LC-ESI-MS/MS study of carvedilol and its stress degradation products. Analytical Methods,2013:5(17):4330-5.
4. Raju B, Ramesh M, Srinivas R, Raju SS, Venkateswarlu Y. Identification and characterization of stressed degradation products of prulifloxacin using LC-ESI-MS/Q-TOF, MSn experiments: Development of a validated specific stability-indicating LC-MS method. Journal of Pharmaceutical and Biomedical Analysis,2011:56(3):560-8.
5. Balbus JM, Boxall ABA, Fenske RA, McKone TE, Zeise L. Implications of global climate change for the assessment and management of human health risks of chemicals in the natural environment. Environmental Toxicology and Chemistry,2013:32(1):62-78.
6. Noyes PD, McElwee MK, Miller HD, Clark BW, Van Tiem LA, Walcott KC *et al*. The toxicology of climate change: Environmental contaminants in a warming world. Environment International,2009:35(6):971-86.
7. Fang M, Ivanisevic J, Benton HP, Johnson CH, Patti GJ, Hoang LT *et al*. Thermal Degradation of Small Molecules: A Global Metabolomic Investigation. Analytical Chemistry,2015:87(21):10935-41.
8. Chieng N, Rades T, Aaltonen J. An overview of recent studies on the analysis of pharmaceutical polymorphs. Journal of Pharmaceutical and Biomedical Analysis,2011:55(4):618-44.
9. Al-Maydama HM, Abduljabbar AA, Al-Maqtari MA, Naji KM. Study of temperature and irradiation influence on the physicochemical properties of Aspirin. Journal of Molecular Structure,2018:1157:364-73.
10. Acharya S, Daniel A, Gyadangi B, Ramsamy S. Isolation, characterization of a potential degradation product of aspirin and an HPLC method for quantitative estimation of its impurities. Journal of Chromatographic Science,2015:53(9):1491-7.
11. Arruda C, Pena Ribeiro V, Oliveira Almeida M, Aldana Mejía JA, Casoti R, Kenupp Bastos J. Effect of light, oxygen and temperature on the stability of artepillin C and p-coumaric acid from Brazilian green propolis. Journal of Pharmaceutical and Biomedical Analysis, 2020, 178(xxxx).
12. Johnsirani P, Wani AA, Bharatam PV, Nanjappan S. LC-ESI-QTOF-MS analysis utilizing gas-phase fragmentation reactions subjected to ESI-IS-CID and ESI-CID-MS/MS conditions to study the degradation behaviour of sorafenib tosylate: NMR and in vitro cytotoxicity and apoptosis detection studies of hydrolytic . Journal of Pharmaceutical and Biomedical Analysis,2020:177:112881.
13. Vishnuvardhan C, Saibaba B, Allakonda L, Swain D, Gananadhamu S, Srinivas R *et al*. LC–ESI–MS/MS evaluation of forced degradation behaviour of silodosin: In vitro anti-cancer activity evaluation of silodosin and major degradation products. Journal of Pharmaceutical and Biomedical Analysis,2017:134:1-10.
14. Swain D, Samanthula G, Bhagat S, Bharatam PV, Akula V, Sinha BN. Characterization of forced degradation products and in silico toxicity prediction of Sofosbuvir: A novel HCV NS5B polymerase inhibitor. Journal of Pharmaceutical and Biomedical Analysis,2016:120:352-63.
15. Chiguru V, Lingesh A, Srinivas R, Satheeshkumar N. Forced degradation study of racecadotril: Effect of co-solvent, characterization of degradation products by UHPLC-Q-TOF-MS/MS, NMR and cytotoxicity assay. Journal of Pharmaceutical and Biomedical Analysis,2016:128:9-17.
16. Yousuf AK. Substrate Temperature Effect on the Structure, Morphological and Optical Properties of CuO / Sapphire Thin Films Prepared by Pulsed Laser deposition. Ibn Al-Haitham Journal for Pure & Applied Sciences, 2014, 27(2).