ORIGINAL ARTICLE

Leaching of plastic polymers by plastic vials used for storing homoeopathic medicines: A preliminary study

Neeraj Gupta¹, R. K. Saxena¹, B. Sharma², S. Sharma², A. K. Agrawal², M. Jassal³, Raj K. Manchanda¹

ABSTRACT

Background: In Homoeopathy, plastic containers/vials are used for the storing/dispensing of ethanol-based medicines instead of glass. Various studies have suggested that plastic components that leach out in stored substances tend to cause contamination and may produce adverse effects in living systems. The present study was aimed to find out chemical composition and leaching behaviour of commonly used plastic vials (PVs) if any during the storage of ethanol-based homoeopathic medicines in optimal environment.

Material and Methods: The experiments were conducted on two sample sets of PVs. Chemical properties of PV were assessed by Fourier Transform Infrared Attenuated Total Reflectance (FTIR-ATR) spectroscopy. PV were cut separately [sample-1 (S-1) and sample-2 (S-2)] and immersed in Homoeopathic Grade Ethanol (HGE) in conical flask and stored for 7 days at ambient temperature (25° ± 5°C) with constant rotary shaking. After 7 days, S-1 and S-2 of PV in Homoeopathic Grade Ethanol (HGE) were decanted and filtered. Aliquots (A1 and A2) were analysed by proton nuclear magnetic resonance spectroscopy (H¹ NMR). The spectral graph obtained by FTIR-ATR spectroscopy for PV compositions and spectral graph obtained by H¹ NMR spectroscopy for PV ethanol aliquots were examined for PVs material and PV leaching effect in HGE.

Results: FTIR-ATR spectra showed that PV are made up of two types of polyolefin’s compounds i.e. Low Density Polyethylene (LDPE) and Linear Low Density Polyethylene (LLDPE). Aliquots of PV in HGE showed the presence benzophenone and its methyl derivative, heat and light stabiliser (2, 2, 6, 6-tetramethylpiperidine and amino derivative), antioxidant (4, 4’-thiobis and 2-tertbutyl-5-methylphenol) and plasticizer bis 2-Diethylhexyl phthalate (DEHP) or Dioctyl phthalate (DOP). Results of study suggest that PVs leach out plastic polymers in HGE.

Conclusion: This preliminary experiment suggests that it is not safe to use LDPE/LLDPE plastic for storing/dispensing ethanol based homoeopathic medicines. Further study with other grades of plastic is desirable.

Keywords: FTIR-ATR and, (H¹ NMR) spectroscopy, Homoeopathic grade ethanol, Leaching, LDPE, LLDPE, Plastic vials, Polymers, Storage
INTRODUCTION

Plastic products of different quality are used for storing and dispensing of homoeopathic medicines instead of glass which is recommended in the classical texts. Several studies found that plastic polymers leach out in stored liquids (water, milk, beverages, etc.) and might cause adverse effects in living beings. Several research studies based on plastics suggest that released or migrated plastic compounds in surrounding are toxic and harmful to human health, in many direct or indirect ways. Phthalates or esters of Phthalic acid are commonly used as plasticisers (substances added to plastics to increase their flexibility). Di 2-ethylhexyl phthalate, dibutyl phthalate, di-isonylnaphthalate, di-isodecyl phthalate, benzyl-butyl-phthalate, diocyl phthalate and di-n-octyl-phthalate are few phthalates generally used in converting polyvinyl chloride from a hard plastic to a flexible plastic. Mother tinctures in Homoeopathy are generally made from animal, plants and metallic compounds and use high purity ethanol because of its excellent solvent properties, inertness and non-toxic nature. There is a possibility that plastic substances may leach out and contaminate homoeopathic medicines stored/ dispensed in plastic containers/vials. Several types of plastics are used such as Low Density Polyethylene, Linear Low Density Polyethylene, High Density Polyethylene. A sophisticated preliminary chemical study has been done to study the leaching properties of commonly used homoeopathic plastic vials (PVs) of LDPE and LLDPE available in the open market and migration of plastic polymers in Homoeopathic Grade Ethanol (HGE) in acute exposure, if any.

MATERIAL AND METHODS

Material

Different kinds of homoeopathic PVs were procured randomly from local vendors/suppliers of homoeopathic materials. Diluent HGE (90%) was obtained from certified homoeopathic dispensing/ manufacturing firm from Delhi for present study.

Methodology

1. Identification of chemical composition of different PVs

PVs procured from local markets were subjected for Fourier Transform Infrared Attenuated Total Reflectance (FTIR-ATR) analysis to identify the chemical composition of plastic material used for manufacturing of vials. It is found that these vials can be distinguished into two categories i.e. having two different chemical compositions of polyolefin’s compounds i.e. Low-Density Polyethylene (LDPE) and Linear Low-Density Polyethylene (LLDPE). These vials were separated and coded as S-1 (LDPE) and S-2 (LLDPE) according to their chemical composition for further study. A typical spectral graph obtained for LDPE PVs by FTIR-ATR is shown in Figure 1.

2. Preparation of S-1 (LDPE) and S-2 (LLDPE) in HGE

PVs i.e. S-1 (LDPE) and S-2 (LLDPE) were cut into small pieces and immersed into homoeopathic grade ethanol (HGE) to investigate its leaching behavior at 25 ± 5°C ambient temperature for 7 days. S-1 (LDPE) and S-2 (LLDPE) were taken by 3.4 wt. % and 6.2 wt. % of total volume of HGE, respectively, as shown in Figure 2 in conical flasks. After 7 days, the HGE from both the samples were decanted separately and evaporated at the 65°C by using Rotary Evaporator to yield...
their residues. Both the residues of S-1 (LDPE) and S-2 (LLDPE) were analysed by H\textsuperscript{1} proton NMR to elucidate their chemical constituents after leaching.

3. Characterisation of residues of S-1 (LDPE) and S-2 (LLDPE) by \textsuperscript{1}H\textsubscript{1}-NMR spectroscopy

Leached out residues of LDPE (S-1) and LLDPE (S-2) PVs were analysed by proton NMR spectroscopy. For every analysis with H\textsuperscript{1} NMR, the instrument was calibrated with CDCl\textsubscript{3} \( \delta \) (ppm) and showed the chemical shift values at 0.00 and 7.19 ppm reference peak for TMS and deuterated chloroform solvent, respectively. In H\textsuperscript{1} NMR spectral graph analysis of S-1 and S-2 residues, it was found a chemical shifts at 7.47, 7.65 ppm and assigned for benzophenone, which is used as ultraviolet (UV) stabiliser. While 4-amino -2, 2, 6, 6-tetra methylpiperidine is used as heat and light stabilisers gives characteristic peaks at 0.84, 1.08, 1.12, 1.18 and 1.79, 3.07 ppm. An anti-oxidant named as 4,4'-thiobis (2-tert-butyl-5-methylphenol) is also present in residue, which gave peaks at 1.28, 2.26, 4.61-4.94, 6.92, 7.01 ppm. On the other hand, the chemical shift values at 0.90-0.92 and 1.27-1.63 and 4.21 ppm correspond to plasticiser Di Octyl Phthalate (DOP). The peaks from 0.90-1.63 ppm overlap with the peaks of 4-amino-2, 2, 6, 6-tetra methylpiperidine and result in high intensity peaks in this range. Besides, numerous small and medium intense NMR peaks exist due to unidentified impurities of sample [Figure 3].

RESULTS

The results suggest that PVs used for storing and dispensing homoeopathic medicines leach out different plastic components and additive compounds. HGE procured from supplier was analysed with proton NMR spectroscopy to confirm its purity as it was used as solvent in present study. Spectral graph obtained by H\textsuperscript{1} NMR spectroscopy of homoeopathic grade ethanol showed definite chemical shift values for ethanol at 1.1 ppm level, i.e. (triplet, CH\textsubscript{3}), 2.4 ppm (singlet, OH) and 3.6 ppm (quadrature, CH\textsubscript{2}), which indicates that ethanol used in the present study contains no impurities [Figure 4].

Preliminary leaching investigation studied the migration of plastic polymers in stored HGE in commonly used PVs for dispensing medicines. Composition of PVs and leached substances in aliquots was analysed by FTIR-ATR and H\textsuperscript{1} NMR spectroscopic techniques. PVs used for dispensing of homoeopathic medicines have been found to be composed of two types of plastic materials LDPE and LLDPE polymers in FTIR-ATR analyser. Whereas, results of stored homoeopathic grade ethanol aliquots (after 7 days) of two types of PVs showed the presence of UV stabilisers (Benzophenone’s), heat and light stabilisers (methylpiperidine’s), antioxidants (methylphenols) and plasticiser (Diocetyl phthalate’s) contents when studied by H\textsuperscript{1} NMR chemical analyser. Results of our short term study (7 days) found leaching of plastic polymers compounds from homoeopathic dispensing PVs in the surrounding in HGE [Table 1]. Several research

Figure 3: Proton nuclear magnetic resonance (NMR) of residue of Sample 1 (low density polyethylene, LDPE)

Figure 4: H\textsuperscript{1} nuclear magnetic resonance (NMR) of homoeopathic grade ethanol spectral graph
studies found adverse effects of leached out plastic polymers in living beings after prolonged use.\textsuperscript{[12-14]}

**DISCUSSION**

In the present preliminary study, leaching/migration of chemical contents in stored rectified ethanol homoeopathic PVs were investigated. Leached substances were analysed and illustrated by modern advanced FTIR-ATR and proton NMR spectroscopic techniques.

Homoeopathic PVs were procured from different local sources, its plastic characteristics were analysed by FTIR-ATR spectroscopy, to ascertain the type of plastic materials used in its development/ manufacturing. It was found that vials are made from two types of plastic polymers, having two different chemical compositions of polyolefin’s compounds i.e. Low-Density Polyethylene (LDPE) and LLDPE. According to the chemical composition of PVs coded as Samples 1 (LDPE) and Sample 2 (LLDPE) for the study.

Homoeopathic grade rectified ethanol (90% by volume) was acquired from certified local homoeopathic dispenser/manufacturer and was used for the study. Chemical composition of rectified ethanol was analysed by proton NMR spectroscopy to assess and identify the purity of rectified ethanol. It is most important to mention that rectified ethanol used should not contain any impurity, so that the results are not altered due to ethanol adulteration. It is observed in rectified alcohol spectra graph that H\textsuperscript{1} NMR (CDCl\textsubscript{3}) \(\delta\) (ppm) showed no chemical shift at 0.00 and 7.24 ppm, to corresponding reference peak for TMS (Trimethylsilane) and deuterated chloroform (CDCl\textsubscript{3}) solvent. The chemical shift values are found at 1.1 ppm (triplet, CH\textsubscript{3}), 2.4 ppm (singlet, OH) and 3.6 ppm (quartet, CH\textsubscript{2}). Rectified ethanol spectra showed that rectified ethanol which is used in present study as solvent has 100% purity and no other peaks were observed in rectified ethanol spectra graph due to impurities.

**CONCLUSION AND RECOMMENDATION**

This experiment has shown that commonly used PVs in homoeopathic practice were composed of LDPE and LLDPE polymers. It reflects that plastic chemicals leach out and contaminate homoeopathic medicines even at 25°C ambient temperature within 1-week period. Hence, it is recommended that PVs of LDPE, LLDPE should not be used for storing and dispensing homoeopathic medicines. Further studies with more stable plastic such as HDPE (Grade 4) are desirable.

**REFERENCES**

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