Hygroscopicity of window materials using terahertz time-domain spectroscopy (THz-TDS)

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***Abstract*—Liquid spectroscopy allows analysis of chemical composition and provides a better understanding of the solvation dynamics of various types of liquid [1]. In liquid spectroscopy, window material is required to contain the liquid samples. A number of papers have been published on absorption coefficient of different types of window materials for liquid spectroscopy [1], [2], [3], however the hygroscopicity of the window material which could potentially increase the absorption coefficient of the window material has not been reported. This paper measures the hygroscopicity of different types of window materials used in terahertz liquid spectroscopy.**

***Index Terms*—Hygroscopicity, terahertz, liquid spectroscopy, T-ray.**

I. Introduction

Over the last decade, there has been an enormous interest in THz spectroscopy of liquids. A number of techniques have been used to measure the transmission properties of liquids using terahertz radiation (T-ray) [1], [2], [3], [4], [5], [6], [7], [8], [9]. In all these techniques, a window material is required to contain the liquid sample. Different types of window materials have been used, however, the challenge is to find a suitable window material that has both excellent T-ray transmission properties and low hygroscopicity. Although the transmission properties of the window material has been reported in the previous paper [1], the hygroscopicity of the window material which could affect the transmission properties has not been reported. Here, we carried out an investigation on the hygroscopicity of different types of window materials for spinning wheel liquid spectroscopy (Fig. 1) as described in [1].

II. Experimental Method

The THz T-ray 2000 from Picometrix experimental setup was used for this experiment. Two sets of same window materials are tested under two conditions: (i) in a dry condition and (ii) in a soaked condition. The window materials are measured statically via the THz-TDS before and after soaking in plain water for approximately 48 hours. Up to 7 potential window materials are tested. The absorption coefficient before and after soaking for polycarbonate, polyvinyl chloride (PVC), and Cycoolefin copolymer 8007 (COC) are plotted in Figure 2. The graph illustrates the difference before and after soaking. The measurement results of 7 different window materials are given in Table 1. These measurements are taken at the frequency of 0.6 THz.

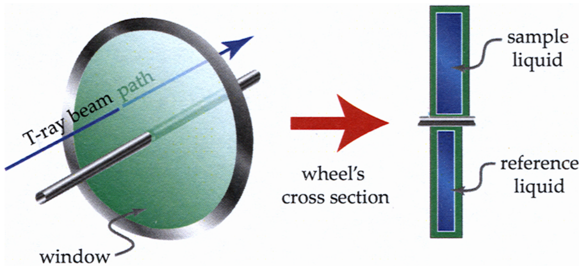

Fig. 1. Spinning wheel with dual-thickness cavity. The idea of the wheel is that it overcomes the uncertainty of the liquid layer thicknesses produced by the lateral dithering [2]. As the wheel has two fixed cavities filled with the sample liquid—one thin and one thick cavity—simple rotation then allows rapid swapping between sample and reference with well-controlled thicknesses. The challenge, however, is to find a suitable window material for the wheel that has both excellent T-ray transmission properties and low hygroscopicity. After [10]

Based on the graph, cycloolefin demonstrates a promising transmission properties and a very low hygroscopicity as a window material for the spinning wheel technique. Due to its excellent properties, this material can also be used in other applications.

III. Result and discussion

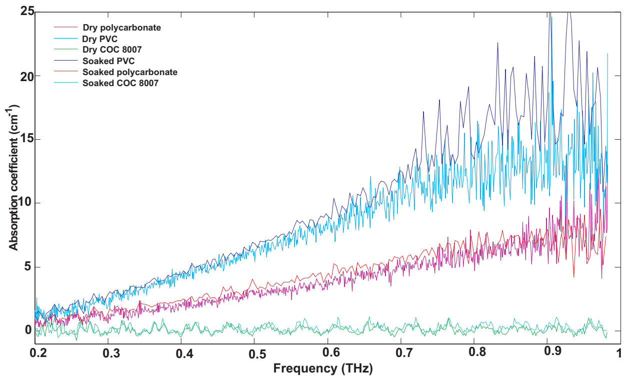

Fig. 2. Illustrates the absorption comparison for polycarbonate, PVC, and COC 8007 before and after soaking in plain water for approximately 48 hours. After soaking, excess surface water is removed. The results show that the cycoolefin absorbed negligible water, whereas the PVC and polycarbonate sample demonstrates slight hygroscopicity which increases the absorption slightly. In Table 1, absorption coefficient of other window materials are given. Based on the table, one possible window material for the spinning wheel could be the HDPE, however, due to its softness, it may not be suitable.

TABLE I
WINDOW MATERIAL α AT 0.6 THZ

Material	α cm^{-1} (dry)	α cm^{-1} (soaked)
Acrylic	4.5	5.7
Nylon	0.21	0.25
Polyethylene	0.1	0.2
Polycarbonate	3.7	4.5
PVC	8.3	9.4
COC 8007	0.1	0.2
Teflon	0.5	1.2

IV. CONCLUSION

In this paper, we have presented the hygroscopicity measurement of window materials for the spinning wheel technique. There are a number of window materials that remain to be explored. As a future work, we would like to investigate on longer soaking period of the window materials which could potentially further increase the absorption coefficient. Investigation on different soaking liquids, such as petroleum, blood and other biological liquids will be carried out in future.

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