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FT-IR Studies of e-plastic obtained from obsolete computers

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ABSTRACT

The present study deals with identification of different polymers present in the plastics obtained from various parts of computer such as CPUs, Keyboards and Monitor etc., manufactured by different producers such as Intex, Compaq, Vista etc. The samples were characterized using FT-IR technology. FT-IR is a superb analytical tool for screening polymer samples. It identifies different functional groups in a molecule by producing an IR absorption spectrum. The test result shows the presence of polymers such as ABS, PPO, PC, and flame retardant etc., in these samples. The assessment of the results of various samples also show that different producers use same qualitative composition, however, they may differ quantitatively.

Keywords: Polymers, FT-IR.

INTRODUCTION

In 21st century, information technology (IT) has become a power house of global economy. It has touched almost all the parts of social, technical, economic and natural environment.

The increasing production of computers, TV's, phones, etc., the progress in their performance and the shorter span of time between innovation and production has led to increasing number of obsolete products. As a result, the quantity of old electronics or e-waste, such as computers, phones, TVs etc., being discarded every year, is growing rapidly. One of the main reasons of rapid production is cheaper prices of these products. It is easy to replace the old item with new one rather than repairing. The low price often means low quality and a very short life span. Thus, the quantity of this waste is increasing dramatically, whereas disposal of this waste has not attracted the desired attention.US is also exporting large quantities of e-waste illegally to developing countries.

The problem of WEEE is not only one of quantity but also the hazardous impact associated with its final disposal. The disposal of electrical and electronic equipments in landfill sites, or through incineration, creates a number of environmental problems because of the presence of various additives such as heavy metals, halogenated flame retardants, etc.

The major portion of e-waste is plastic often called e-plastic. The recycling of e-plastic is very difficult because of diversity of polymeric materials used, i.e., thermoplastic as well as thermosets, and relatively high level of flame retardants (halogen containing compounds) added during production. More than 90% of such waste is currently landfilled as it is quite difficult to recycle it. So, while trying to recover the plastic material from discarded electronic devices, one has to take into consideration the high halogen, N and S contents due to additives such as flame retardant. Another fact is that the thermosets polymers cannot be remolded or reprocessed by remelting. Thermosets composites contain high amount of inorganic glass reinforcement or mineral fillers. In this case, chemical recycling could be carried out to obtain some organic products and recover the reinforcement filler. Incineration is not applicable because of presence of large amount of FR's which generate toxic substances during combustion. Hence, analysis of polymer alloy and blends has become an emerging field of research for management of plastic waste.

Keeping in view the above facts, an attempt has been made during the present studies to analyze the polymers present in the computer plastic waste for ascertaining whether it will be miscible with bitumen.

Literature studies show that a typical desktop computer consists of maximum fraction (app. 23%) of plastic [1]. The plastic constitutes approximately 23% of a typical desktop computer. Of this 23%, a residential electronics recycling pilot project found that the most common plastics used in collected PCs were: Acrylonitrile Butadiene Styrene (57%), Polyphenylene Oxide (36%), High-Impact Polystyrene (5%), and Polycarbonate/Acrylonitrile Butadiene Styrene Blend (2%).PVC plastic is not present in PCs in significant amounts[2].
The composition of these plastics is given in table 1.

Table 1: Composition of plastics in computers

Plastic	%age
ABS	57
HIPS	5
PC/ABS	2
PPO	36
PVC	trace

Source: American Plastics Council

Many polymeric materials are used in electronic equipments, but two important components of these products are polycarbonate (PC) and acrylo-nitrile-butadiene-styrene blends (ABS) [3]. PC is a thermosets plastic which comes under the category of epoxy resins. It shows very effective flame retardant properties. This is the reason it is widely used in electrical and electronic appliances. It also shows high impact strength and high stability under different environmental conditions.

ABS provides chemical resistance, heat resistance and toughness while butadiene provides impact strength and styrene provides rigidity and easy processing. Blends of these polymers are of low cost and provide excellent mechanical properties.

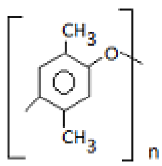
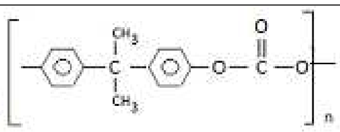
ABS/PC mixtures are quite complex since the system can be considered as a physical blend of two materials with of different nature, a high toughness homopolymer PC, and a great consumption material, such as ABS which consists of poly (styrene-acrylonitrile)(24% by wt. acrylonitrile) block copolymer (SAN) matrix in which polybutadiene spheres of elastomeric nature are dispersed.[4]

WEEE consists of thermoplastics HIPS (high impact polystyrene), acrylonitrile-butadiene-styrene terpolymer ABS, ABS-PC blend for casings and thermosets (epoxy resins) as a major component of PCB's (Printed circuit Boards). [5]

Around 30% of WEEE plastics contain flame retardants [6], which are mostly based on polybrominated aromatic compounds such as TBBA (Tetrbromobisphenol-A), PBDE, etc.

It is, therefore, reasonable to believe that the e-waste consists of ABS, PC, HIPS, and PPO. The structures of monomeric units of these polymers are listed in table 2.

Table 2: Structures of monomeric units of different polymers present in e-plastic

S. No.	Name of polymer	Monomeric units in the polymer and their structure
1.	**ABS**	Acrylonitrile – $CH_2=CH-CN$ Butadiene - $CH_2=CH-CH=CH_2$ Styrene - $C_6H_5-CH=CH_2$
2.	**HIPS**	Styrene - $C_6H_5-CH=CH_2$
3.	**PPO**	Phenylene oxide 
4.	**PC**	Bisphenol A and carbonate ion 

EXPERIMENTAL SECTION

Different parts of obsolete desktop computer such as key boards, CPUs and monitors of different manufactured by various producers such as Intex, Vista, Compaq and TVS were collected from a computer centre.

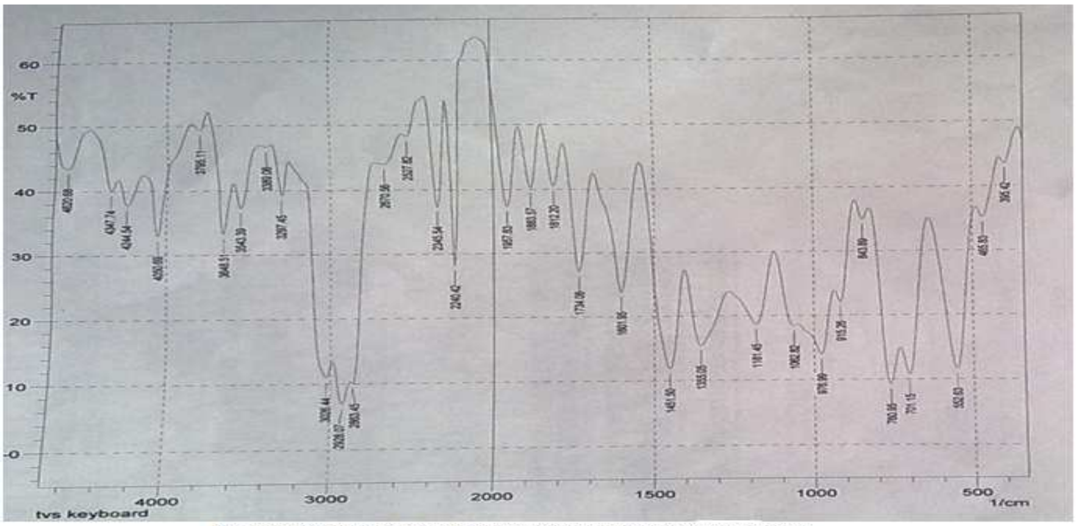


Fig. 1 FT-IR spectra of polymers obtained fromkeyboard of TVS company

Various parts of computers were dismantled very carefully to separate plastics from them. This plastic is called e-plastic. Disassembly of computers revealed that they are composed of around 25% plastic. The e-plastic thus obtained was first crushed into small pieces of varying sizes (around 5mm to 10mm). These small pieces were than powered in a grinder to obtain the sample. FT-IR is an important tool for characterization of e-plastic waste and helps in rendering valuable information regarding functional groups and structure of the polymer. All these samples were characterized by scanning their FT-IR spectra.

Specifications of Instrument

The FTIR spectra of the samples were scanned on SHIMADZU, Model- IR affinity-1 using the KBr pallet. The FT-IR spectra are obtained for Keyboards, CPUs and monitor are given in fig. (1-7).

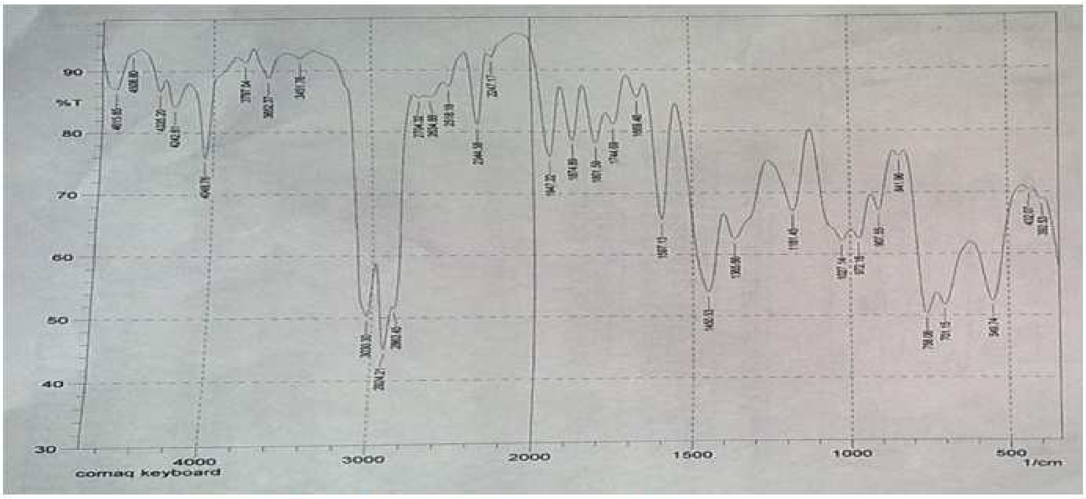


Fig. 2 FT-IR spectra of polymers obtained fromkeyboard of compaq company

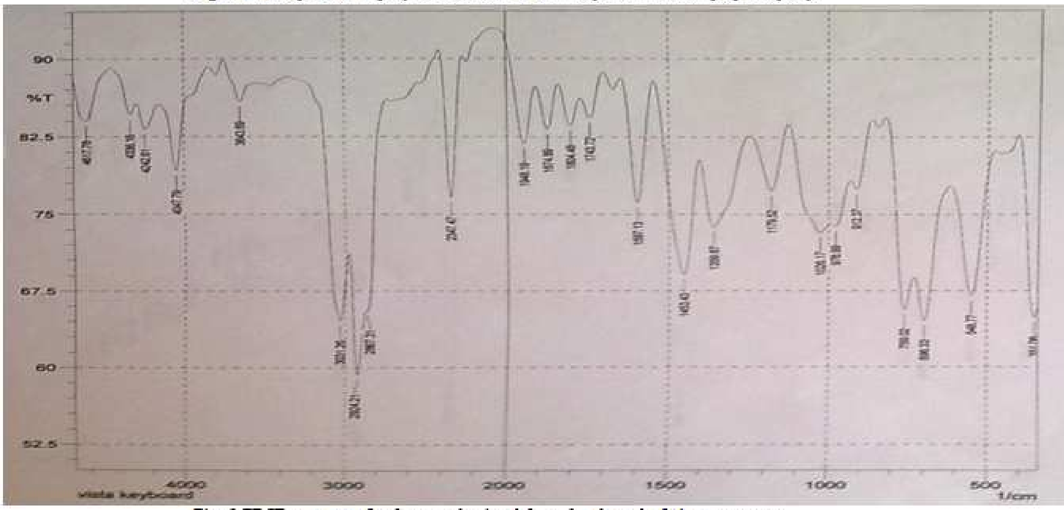


Fig. 3 FT-IR spectra of polymer obtained from keyboard of vista company

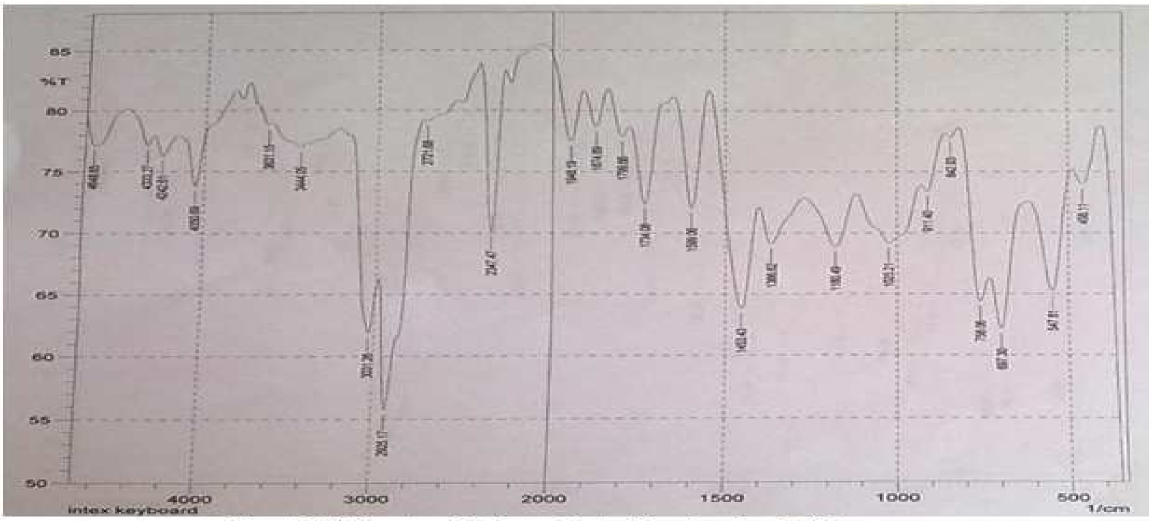


Fig. 4 FT-IR spectra of polymer obtained from keyborad of Intex company

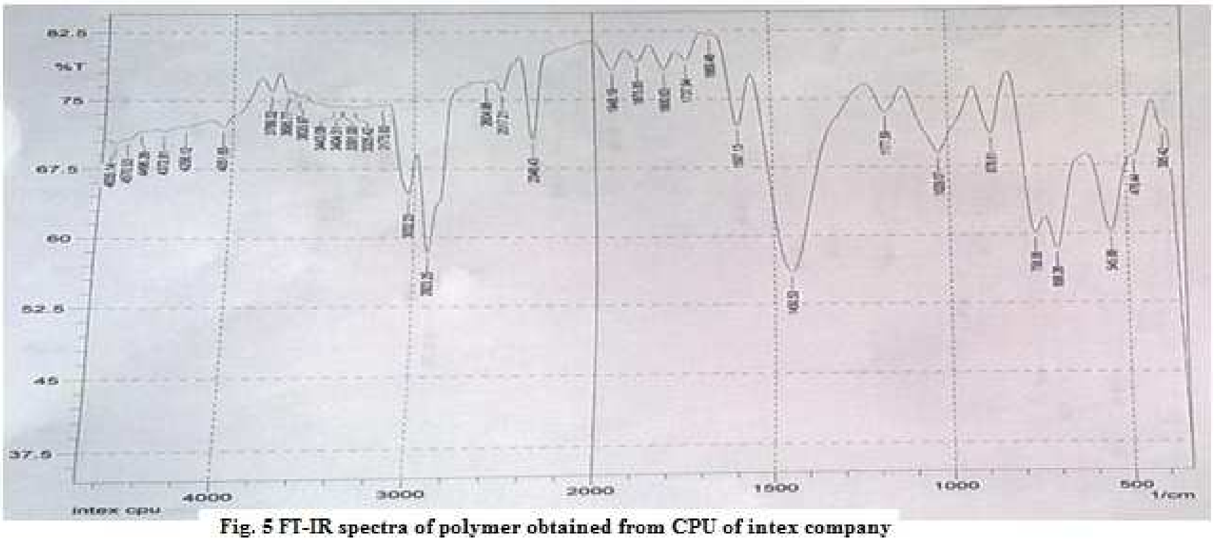


Fig. 5 FT-IR spectra of polymer obtained from CPU of intex company

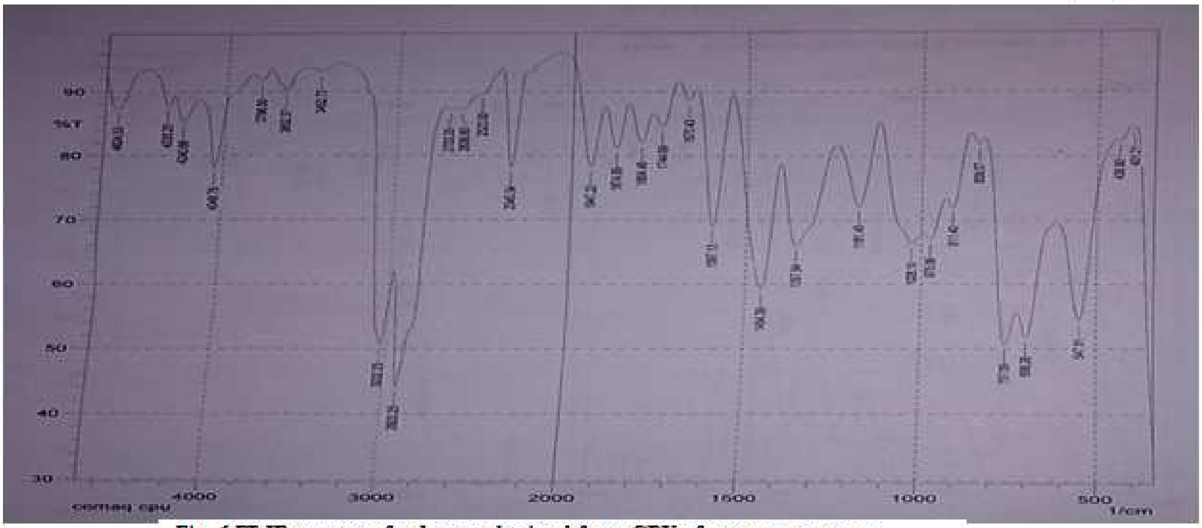


Fig. 6 FT-IR spectra of polymer obtained from CPU of compaq company

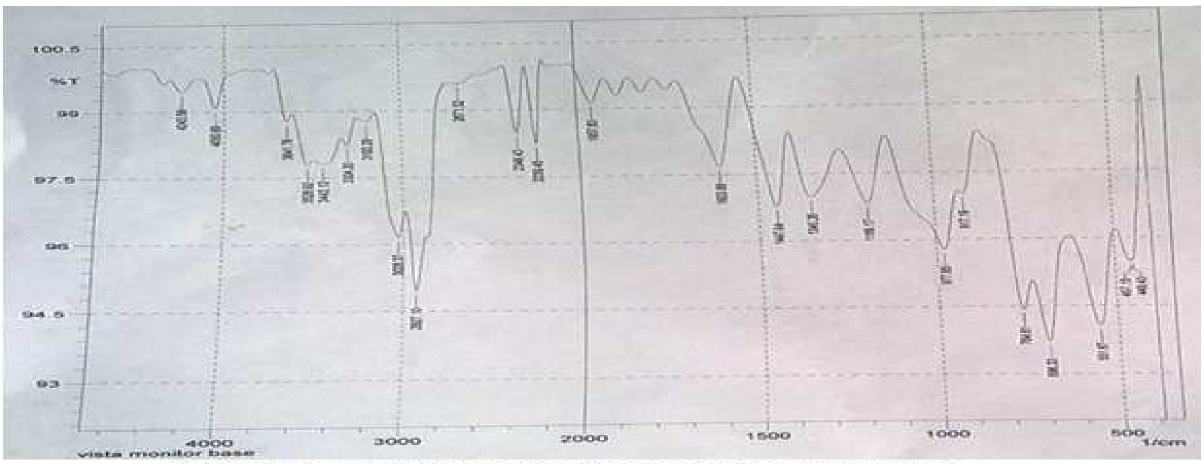


Fig. 7 FT-IR spectra of polymer obtained from monitor base of vista company

RESULTS AND DISCUSSION

Sample name & No. → / Sr. No. ↓	TVS Keyboard (1)	Compaq Keyboard (2)	Vista Keyboard (3)	Intex Keyboard (4)	Intex CPU (5)	Compaq CPU (6)	Vista Monitor Base (7)	Inference
1.	552	549	548	547	545	547	553	C-Br stretch
1.	701	701	696	697	696	698	702	monosubstituted benzene ring
2.	760	758	759	758	758	757	758	
3.	843	841	840	842	878	839	839	p-substitution
4.	976	972	976	911	970	975	986	C=C, trans tetrasubtituted
5.	1062	1027	1026	1025	1029	1028	1040	C-O stretch ester/ether
6.	1181	1181	1179	1180	1177	1181	1187	
7.	1601	1597	1597	1599	1597	1597	1602	C=C stretch aromatic
8.	1734	1744	1743	1734	1737	1744	1738	C=O stretch
9.	2240	2247	2347	2347	2348	2345	2239	
10.	2863	2863	2867	2850	2855	2850	2860	C-H stretch aliphatic
11.	2928	2924	2924	2925	2923	2923	2926	
12.	3026	3030	3031	3031	3032	3032	3030	C-H stretch, aromatic
14.	3648	3652	3643	3631	3635	3652	3642	O-H stretch, free

A careful analysis of FT-IR spectra of various samples revealed that almost all of them are composed of ABS, HIPS, PC, PPO, Polybutadiene and the flame retardant TBBA.

The presence of ABS was revealed by characteristic vibrations at 3032-3026 cm^{-1} (C-H stretch, aromatic), 2926-2923 cm^{-1} and 2867-2863 cm^{-1} (C-H stretch, CH_3 and CH_2); the band 2867-2863 cm^{-1} appearing as a shoulder in case of samples. 4-7). 2348-2239 cm^{-1} C≡N Stretch, 1602-1597(C=C stretch aromatic) ,982-972 cm^{-1} (OOP C-H bending ,tetra substituted C=C, trans), here it may be mentioned that in case of sample 5,this band appeared as a shoulder of the band 1025cm^{-1}; 702-696 cm^{-1} and 760-757 cm^{-1} (monosubstituted benzene ring).

The appearance of bands at 3032-3026 cm^{-1} (C-H stretch aromatic), 2926-2923 cm^{-1} and 2867-2863 cm^{-1} (C-H stretch, CH_3 and CH_2); the later appearing as a shoulder in the case of samples 4 to 7; 1602-1597 cm^{-1} (C=C stretch, aromatic); 702-696 cm^{-1} and 760-757 cm^{-1} (monosubstituted benzene ring) can be taken as reasonable evidence for the presence of HIPS also in these samples.

The presence of PC was ascertained by the appearance of characteristic ester bands at 1744-1734 cm^{-1} (C=O stretch);1602-1597 cm^{-1} (C=C stretch aromatic)); 1062-1028 cm^{-1} and 1187-1177 cm^{-1} (C-O stretch ester/ether); here it may be mention in case of sample 7,this band appeared as a shoulder of the band 986 cm^{-1} band.Further confirmation of its presence was provided by typical absorptions at 3032-3026 cm^{-1} (C-H stretch, aromatic),2926-2923 cm^{-1} and 2867-2863 cm^{-1} (C-H stretch CH_3), 843-839 cm^{-1} (*p*-substitution).
The presence of PPO was shown the appearance of bands at 3032-3026 (C-H stretch, aromatic), 2926-2923 cm^{-1} and 2867-2863 cm^{-1} (C-H stretch CH_3), 1602-1597 cm^{-1} (C=C stretch,

aromatic); 1062-1028 cm^{-1} (C-O stretch ester/ether);); here it may be mention in case of sample 7,this band appeared as a shoulder of the band 986 cm^{-1} band.

The presence of polybutadiene was in conformity with the appearance of a band in the range 982-972 cm^{-1} (OOP C-H bending, tetrasubstituted olefin, *trans*).

Further the analysis of IR spectra of all the above samples revealed the presence of TBBA as evidenced by appearance of the typical C-Br stretching vibration in the range 553-545 cm^{-1} . This was further supported by the appearance of characteristic band in the range 3652-3631 cm^{-1} (sharp, weak O-H stretch, free).

CONCLUSION

Based on the laboratory test results and their analysis, the following conclusions are drawn:

1. The comparative studies of IR spectras of different computer parts such as keyboard, CPU and monitor companies manufactured by different producers such as TVS, Intex, Compaq and Vista have established the presence of ABS,PPO,PC,HIPS, polybutadiene and TBBA in all the samples.
2. The characteristic bands shown by the different samples are same but have different intensities. It shows that these are same qualitatively but vary quantitatively.

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