Identification Characteristics for Amber and its Imitation

Hui Li[a], Xuan Wang[b], Yong Zhu[c]

Chongqing Academy of Metrology and Quality Inspection, Chongqing 401123, China

[a]lihui@cqu.edu.cn, [b]13667669535@163.com, [c]13883583338@163.com

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Abstract. Amber, copal resin and anime belong to the natural resin formed in different geologic age, which are similar and transitional in the physical and chemical properties. The artificial heat-pressurized treatment copal, synthetic resin, pressing amber and covering film amber are similar to amber in the gemological parameters. It is very difficult to identify amber from these imitation only based on the gemological parameters. In this paper, amber and its imitation samples were tested by means of Fourier transform infrared spectroscopy (FTIR) and Differential scanning calorimetry (DSC) to explore the attribution of peaks so as to obtain the difference between the amber and its imitation. The results show that the difference of infrared spectra between amber and natural resin is that the amber has characteristic absorption peaks of aliphatic structure, while natural resins such as copal resin and anime have a weak absorption band at 3073 cm^{-1} caused by telescopic vibration of *v* (CH), absorption band at 1641cm^{-1} caused by telescopic vibration of *v* (C═C), and absorption band at 888 cm^{-1} caused by bending vibration of γ (CH) for benzene ring. The infrared spectras between the amber and the synthetic resin indicate that there are great differences between 2800-3000 cm^{-1} and 500-1500 cm^{-1}; and I (2933cm^{-1}) /I (1725cm^{-1}) of infrared spectrum for pressed amber is about 1.5, while I (2934cm^{-1})/I (1725cm^{-1}) of amber is about 3.0. The DSC thermogram for the heat pressurized treatment copal resin only exists exothermic peak and its evident exothermic peak is at about 150 ℃, which there is evident difference from the endothermic peak for the amber.

Introduction

Amber is a natural resin fossilized by various geological formation. At present, there are usually 3 types of amber imitations in the market, which are natural resin, synthetic resin and other imitation. Based on different geologic age of formed natural resin, they are copal resin, anime and rosin, but rosin dose not have the geological effect. Synthetic resin is a high molecular weight resin formed by artificial polymerization and polycondensation reaction. Other imitations are mainly artificial heat- pressurized treatment (HPT) copal resin, reconstituting amber, pressing amber and covering film amber. Three types of amber imitations are similar to amber in the gemological parameters. It is very difficult to identify amber from its familiar imitations only based on the gemmological parameters[1-12]. In this paper, amber and its common imitation samples were tested by means of Fourier transform infrared spectroscopy (FTIR) and Differential scanning calorimetry (DSC), in order to analysing the kinds and characteristics of carbon functional group in amber and searching for difference between amber and its imitation samples, for identification between amber and its imitation provide a scientific basis.

Experiments

Specimens and Experiment Method.

Two amber samples respectively from Dominican and Baltic, two copal resin samples respectively from Indonesia and Colombia, two heat-pressurized treatment copal resin samples respectively from Colombia and Indonesia, and anime, reconstituting amber, pressing amber and covering film amber from the market.

IR spectra were recorded from KBr pellets in the 4000 – 500 cm^{-1} range using a Nicolet IS 10 spectrometer, at a resolution of 4 cm^{-1}, scanning time 32s. Differential scanning calorimetry (DSC) thermograms were recorded using a Mettler-Toledo TGA / DSC / 1100 / FL simultaneous thermal analyzer, at a heating rate of 5℃ min^{-1}, and 200 mesh powder samples for 10mg under nitrogen.

Results and Discussion

The gemological characteristics of amber and its imitation.

The gemological characteristics of amber and its imitation samples are shown Table 1, which natural resin, synthetic resin, heat-pressurized treatment copal resin, reconstructed amber, pressed amber and covered film amber are almost consistent with amber in refractive index (R.I.) and density, and they are respectively in the range from 1.53 to 1.56 and from 1.03 to 1.06. The sample fluorescence caused by long-wave ultra-violet light（LW Fluorescence）and orthogonal polarization observing are not typical. The soluble test in alcohol and ethyl ether show that amber is completely insoluble, copal resins is soluble in alcohol but not obvious in ethyl ether, and anime sample is of good solubility.

Table 1. Gemmological characteristics of amber and its imitation samples

No	Name	Colour	Density	R.I.	Orthogonal polarization	LW Fluorescence
1	Amber	Golden	1.04	1.55	Anomalous extinction	Blue and white
2	Copal resin	Light yellow	1.03	1.54	Anomalous extinction	Blue and white
3	Anime	Orange	1.06	1.53	Anomalous extinction	Yellow green
4	HPT copal resin	Green	1.05	1.54	Anomalous extinction	Blue and white
5	Synthetic resin	Orange	1.06	1.56	Anomalous extinction	Blue and white
6	Reconstituting amber	Tan	1.06	1.55	Anomalous extinction	Yellow
7	Pressing amber	Brown	1.06	1.54	Anomalous extinction	Yellow green
8	Covering film amber	Tan	1.05	1.55	Anomalous extinction	Brown

The infrared spectrnm of amber.

The infrared absorption spectrum of amber from Dominican is shown in Fig. 1, which the basic skeleton of amber is aliphatic structure, asymmetric telescopic vibration of v (CH_2) located at 2928cm^{-1}, symmetric telescopic vibration of v (CH_2) located at 2865cm^{-1}, transformative vibration of δ（CH_2, CH_3）located at 1465cm^{-1}, the symmetric transformative vibration of δ（CH_2, CH_3）located at 1381cm^{-1}, and telescopic vibration of v（C=O）located at 1726cm^{-1}, and telescopic vibration of v（C—O） located at 1244cm^{-1}, 1135$cm^{-1}$and 1031cm^{-1}.

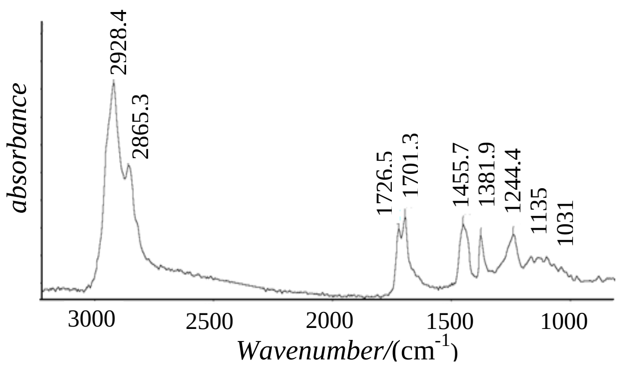

Fig. 1 Infrared spectrum for Dominican amber

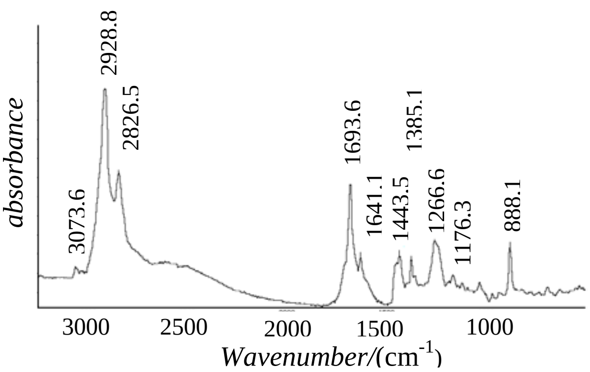

Fig. 2 Infrared spectrum for Colombia copal

The infrared spectrum of copal resin.

The geologic age of formed copal resin is later than amber, it generally contains a small amount of unsaturated hydrocarbons. The infrared absorption spectrum of copal resin from Colombia is shown in Fig. 2, which telescopic vibration of v (CH) located at 3073cm^{-1}, telescopic vibration of one double bond v (C═C) located at 1641cm^{-1}, and bending vibration of γ（C-H） located at

888cm^{-1} for the characteristic bands, and the rest of the main infrared absorption is basically the same as amber.

The infrared spectrum of anime.

The geologic age of formed anime is later than copal, it usually contains unsaturated bond. The infrared absorption spectrum of anime is shown in Fig. 3, which consists of a set of infrared absorption band with a funnel shape feature from 2500cm^{-1} to 3500cm^{-1}, and it is evident difference between amber and copal resin. The Fig.3 indicates that telescopic vibration of ν (CH) located at 3077cm^{-1}, asymmetric telescopic vibration of ν (CH_3) located at 2964cm^{-1}, asymmetric telescopic vibration of ν (CH_2) located at 2927cm^{-1}, the symmetric telescopic vibration of ν (CH_2) located at 2873cm^{-1}, telescopic vibration of one double bond ν (C═C) located at 1641cm^{-1}, transformative vibration of δ(CH_2, CH_3)located at 1471cm^{-1}, and bending vibration of γ(C-H) located at 888cm^{-1}. Anime is the infrared absorption near 3077 cm^{-1}, 1641cm^{-1}, and 888cm^{-1} for the characteristic bands.

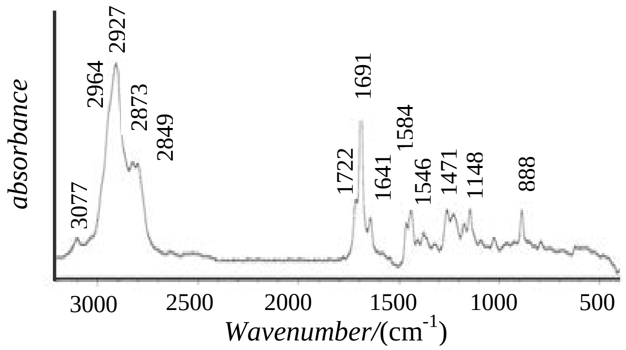

Fig.3 Infrared spectrum for anime

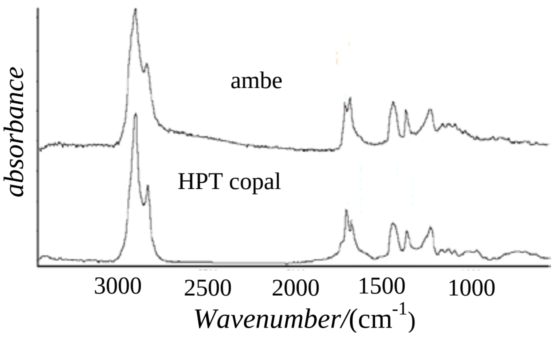

Fig.4 IR spectra for HPT copal resin and amber

The differential scanning calorimetry (DSC) of HPT copal resin.

The artificial heat-pressurized treatment (HPT) is contributed to the polymerization of the natural copal, and turns into green, yellow-green copal. The corresponding infrared absorption spectra at 3073cm^{-1} ν (CH),1641cm^{-1} ν (C═C) and 888cm^{-1} γ(C-H) disappear, which infrared spectrum is almost the same as amber (see Fig.4), so the heat pressurized treatment copal resin can not be effectively distinguished from the amber by FTIR. The DSC thermograms for Dominican and Baltic amber are shown in Fig. 5, which endothermic transitions around 123 ~ 132℃, 389 ~ 465℃ and exothermic transitions around 404 ~ 436 ℃ are observed. The DSC patterns for the heat pressurized treatment copal is shown in Fig. 6, which only exists exothermic peak and its evident exothermic peak is near 150 ℃, and there is evident difference from the endothermic peak for the amber.

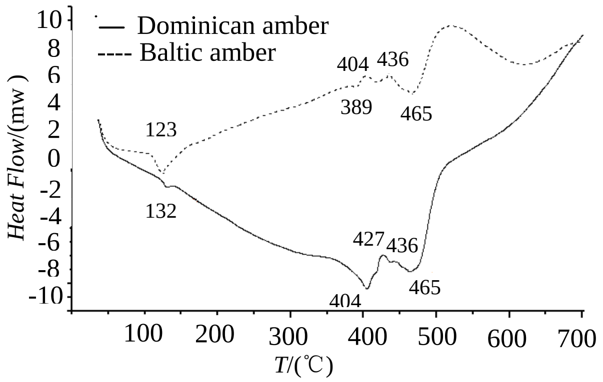

Fig. 5 DSC curves for ambers

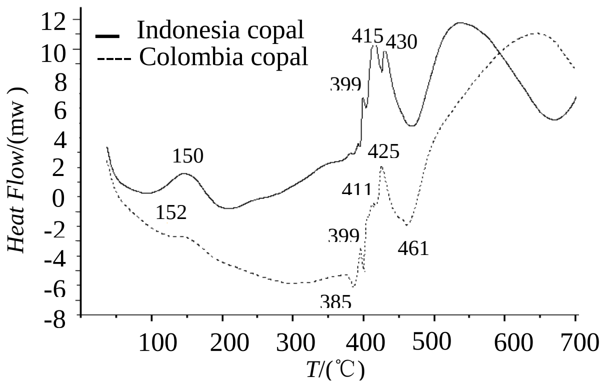

Fig. 6 DSC curves for HPT copal resins

The infrared spectrum of synthetic resin.

The infrared absorption spectrum of synthetic resin is shown in Fig. 7, which B part is much higher than A part; the half peak width is narrow at 1728cm^{-1} and the absorption peak located at 701cm^{-1}. The infrared spectras between the amber and the synthetic resin indicate that there are great differences in 2800-3000 cm^{-1} and 500-1500 cm^{-1}.

The infrared spectrum of reconstructed amber.

Due to a number of amber debris are too small, they can not be directly used to make jewelry, press amber debris in low pressure so as to form chunks of amber. The infrared spectra of reconstructed amber is consistent with amber, but they could be identified by amplifying observation. Infrared spectrum of reconstructed amber is shown in Fig. 8, which the half peak width is narrow at 1753cm^{-1}, B part is higher than A part, and the peak shape and peak position have a great change, indicating that the sample was added synthetic resin while pressing amber debris.

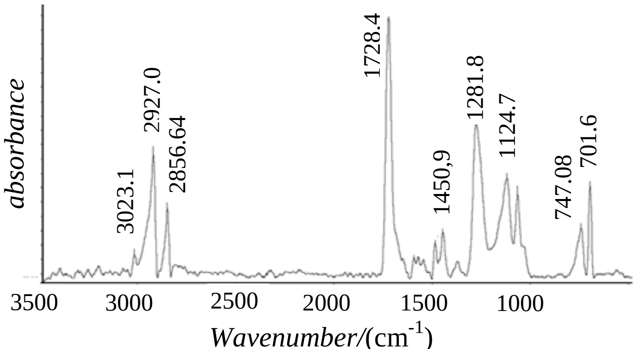

Fig. 7 IR spectrum for synthetic resin

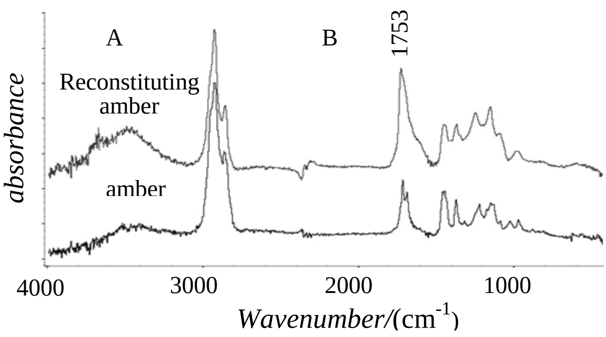

Fig. 8 IR spectra for reconstructed amber and amber

The infrared spectrum of pressed amber.

With the improvement and innovation of optimization treatment techniques of amber, press amber debris under the condition of low temperature and high pressure so as to form chunks of amber, which is difficult to identify by amplifying observing. The infrared spectra of pressed amber is shown in Fig. 9, which is basicly consistent with amber, but the relative absorption intensity (I) for asymmetric telescopic vibration of v (CH_2) located at 2933cm^{-1} decreases, the relative absorption intensity (I) for telescopic vibration of v（C=O）double bond located at 1725cm^{-1} increases, and I(2933cm^{-1})/I (1725cm^{-1}) is about 1.5, while I (2934cm^{-1})/I (1725cm^{-1}) of Dominican amber is about 3.0, so illuminates that pressed amber is heated treatment[13].

The infrared spectra of covered film amber.

The surface of amber is covered by the synthetic resin, which is to achieve the effect of increase transparency and weight so as to change the appearance of amber. The infrared spectra of covered film amber is shown in Fig. 10, which the infrared spectra of covered synthetic resin is evident difference from amber.

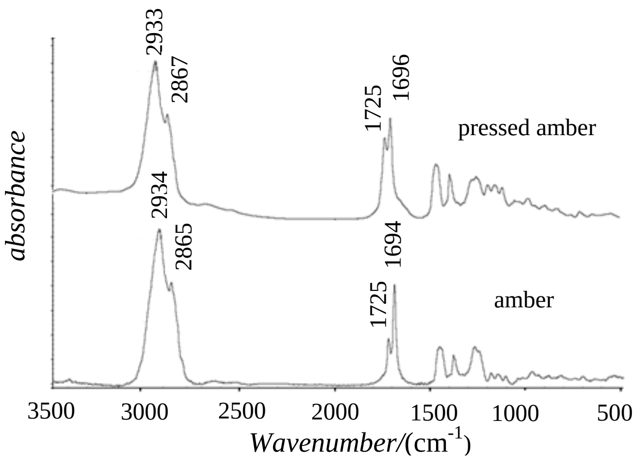

Fig. 9 IR spectra for pressed amber and amber

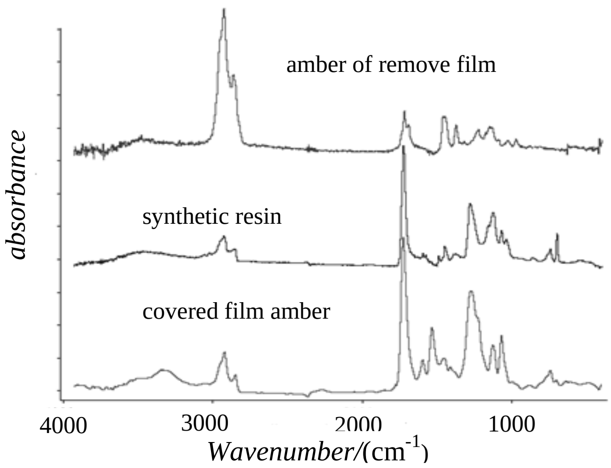

Fig. 10 IR spectra for covered film amber

Discussion

Due to the geologic age of formed copal resin and anime are later than amber, they generally contain a small amount of unsaturated hydrocarbons, which telescopic vibration of *ν* (CH) located at 3073cm^{-1}, telescopic vibration of one double bond *ν* (C═C) located at 1641cm^{-1}, and bending vibration of γ（C-H） located at 888cm^{-1} for the characteristic bands. The infrared absorption spectrum of anime consists of a set of infrared absorption bands with a funnel shape feature from 2500cm^{-1} to 3500cm^{-1}, and it is evident difference between amber and copal resin. Due to the polymerization, the infrared spectrum of the heat-pressurized treatment copal resin is almost the same as amber, but the DSC thermogram for the heat pressurized treatment copal only exists exothermic peak, which there is evident difference from the endothermic peak for the amber. The exothermic peak reveal occurs as chemical degradation and hot oxidation reaction, and it is the reason that the heat pressurized treatment copal exists significantly exothermic peak at about 150℃[14], which is of great significance in the identification. The infrared spectra of pressed amber is basically consistent with amber, but the changes of the relative absorption intensity for pressed amber associated with its thermal oxidation. The absorption intensity reduced at 2930 cm^{-1} indicates that saturated C-H functional group was consumed by the heat, and the absorption intensity increased at 1725 cm^{-1} demonstrates that increased in the concentration of C═O functional group.

Conclusion

1) The difference of infrared spectra between amber and natural resin is that amber has characteristic absorption of aliphatic texture, while natural resin such as copal resin and anime have a weak absorption band at about 3073 cm^{-1} caused by telescopic vibration of *ν* (CH), absorption band at 1641cm^{-1} caused by telescopic vibration of *ν* (C═C), and absorption band at 888 cm^{-1} caused by bending vibration of γ (CH) for benzene ring. The infrared absorption spectrum of anime consists of a set of infrared absorption bands with a funnel shape feature from 2500cm^{-1} to 3500cm^{-1}, and it is evident difference from amber and copal resin.

2) The DSC thermogram for the heat pressurized treatment copal only exists exothermic peak and its an evident exothermic peak is at 150 ℃, which there is clear difference from the endothermic peak for the amber.

3) The infrared spectra between the amber and the synthetic resin indicate that there are great differences between 2800-3000 cm^{-1} and 500-1500 cm^{-1}.

4) The infrared spectra of pressed amber is basicly consistent with amber, but I (2933cm^{-1}) /I (1725cm^{-1}) is about 1.5, while I (2934cm^{-1})/I (1725cm^{-1}) of Dominican amber is about 3.0, so illuminates that pressed amber is heated treatment.

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