FTIR monitoring of artificial ageing of commercial acrylic and vinyl adhesives / consolidants

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INTRODUCTION

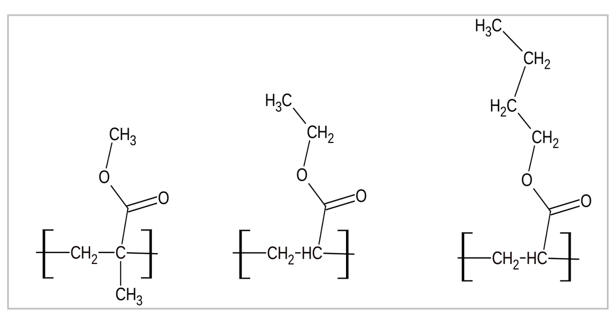
Thermoplastic polymers such as acrylic and vinyl resins are frequently used as consolidants, adhesives and protective coatings in restoration of works of art. The degradation characteristics of these materials in environments similar to these in their actual use are important for their followed application practice in museum objects and architectural constructions. FTIR spectroscopy has been extensively used as a fast and efficient tool for monitoring structural changes of polymers under various conditions.

The stability of two acrylic and a vinyl commercial resin is here comparatively tested under various artificial ageing conditions such as heat (oven set at 50ºC), light (UV lamp with maximum output at 254 nm), and moisture (RH=99%).

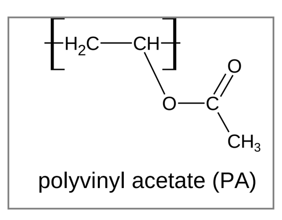
Acrylate1 is composed of a methyl methacrylate (MMA), ethyl acrylate (EA) and ethyl methacrylate (EMA) copolymer

Acrylate 2, is composed of methyl methacrylate (MMA) and butyl acrylate (BA) copolymer

Vinyl 1 is basically Poly(vinylacetate) or PVA.



pMMA pEA pBA



Monomer units

Two series of specimen of the above three materials were tested:

Series 1: thick films of acrylates and vinyl resin on glass substrate

Series 2: acrylate and vinyl resins in mural supporting ground consolidated with each resin.

FTIR spectra were recorded under the artificial ageing conditions at various intervals up to the designated (see spectra) typical exposure.

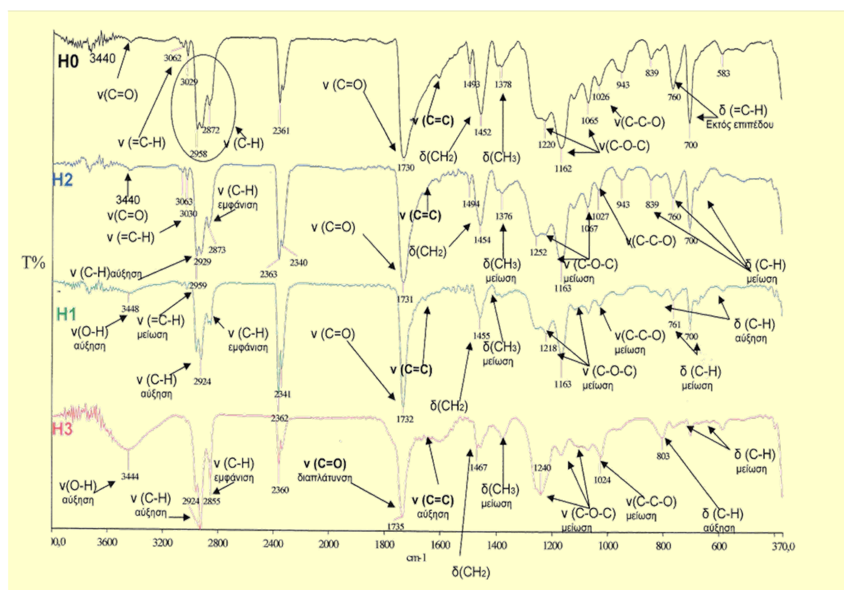
Commercial formulations of acrylic and vinyl resins may include stabilizers, biocides, UV-absorbers and/or corresponding residual monomers in a small percentage, which may affect the overall behavior in every case.

The objective of this study is the comparison of different commercial resins with the use of FTIR spectroscopy under various conditions and the examination of their stability in realistic environments with regard to their use. It is our hope that this will further help in the use of such polymeric materials and will be a valuable tool in the restoration and preservation of works of art.

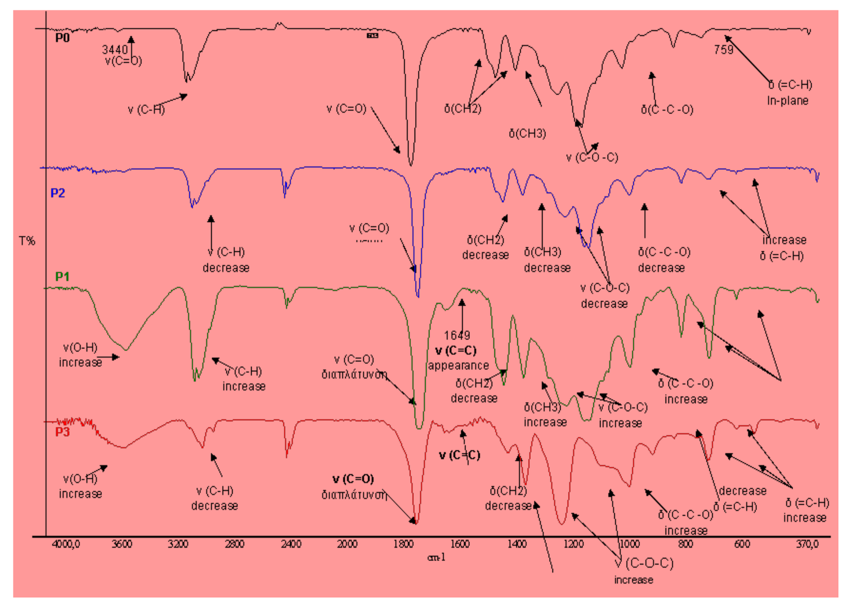
FTIR SPECTROSCOPY

Samples on Glass Substrate

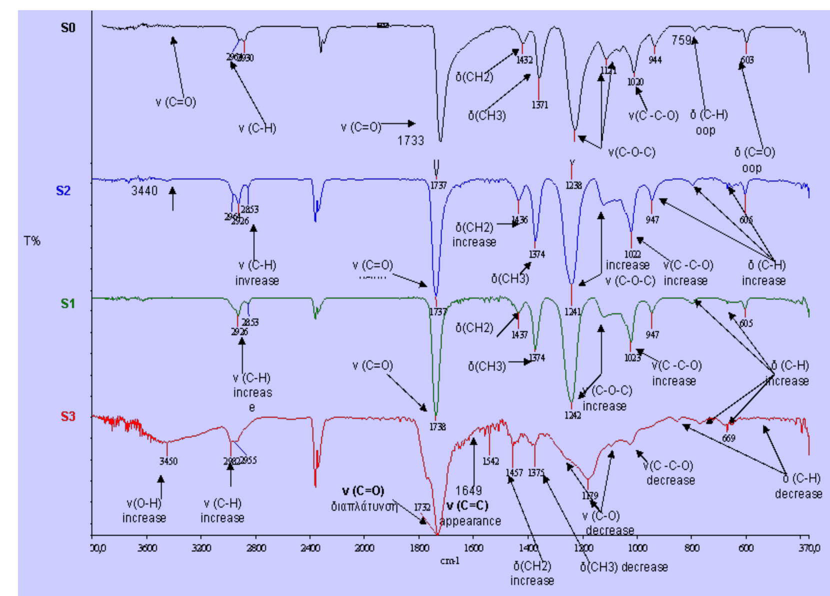
Samples of acrylate 1 and 2 and vinyl 1 were film-cast on glass substrate and were accordingly subjected to artificial ageing: (1) thermal (oven) at 50° C for seven months, (2) humidity (95% RH) for five months and (3) UV lamp for seven months



Acrylate 1 on glass: H0 initial; H1 heating (oven) at 50° C; H2 humidity (95% RH) and H3 UV lamp



Acrylate 2 on glass: P0 initial; P1 heating (oven) at 50° C; P2 humidity (95% RH) and P3 UV lamp



Vinyl 1 on glass: S0 Initial; S1 heating (oven) at 50° C; S2 humidity (95% RH) and S3 UV lamp

Summary of FTIR Results of Samples on Glass

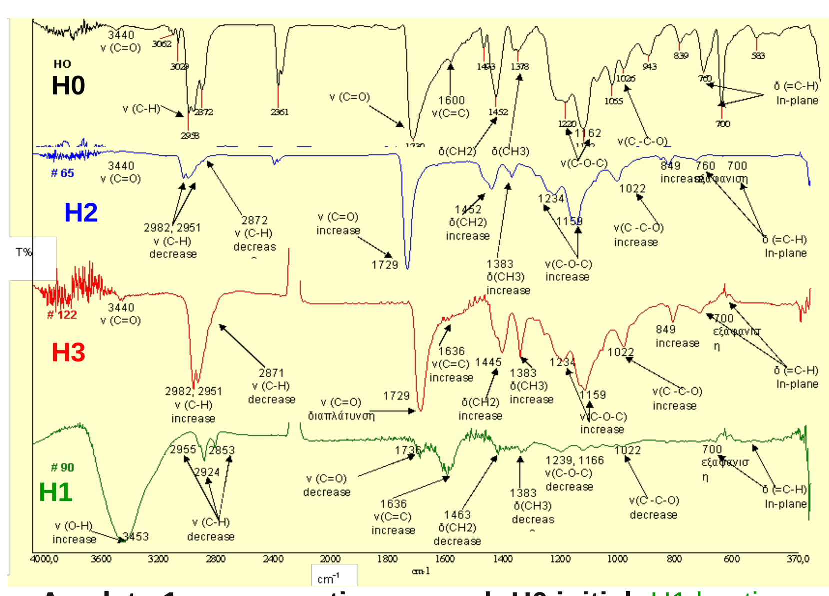
Moisture environment: samples on glass substrate showed no significant changes.

Thermal Ageing: caused changes (formation of hydroxyl groups, carbonyl band widening and C=C unsaturation) mainly in the acrylic materials.

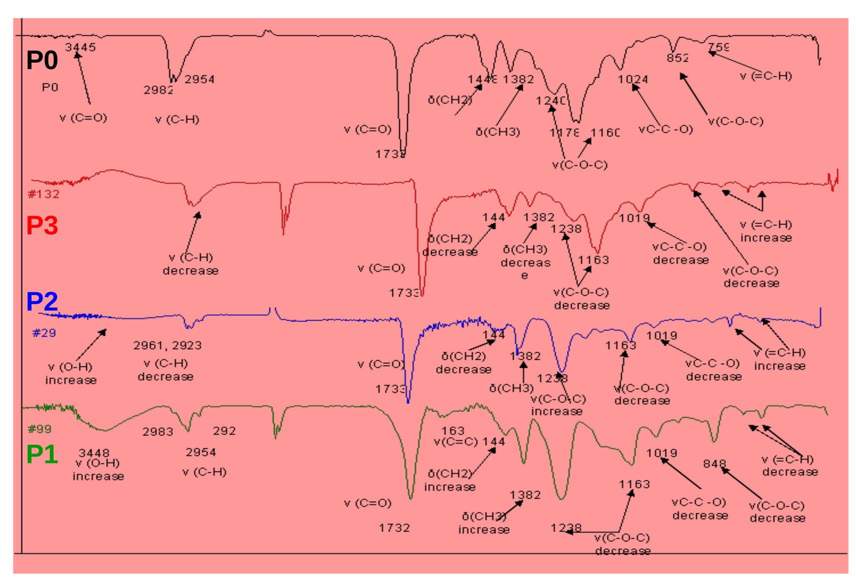
Photochemical Ageing: caused major reduction of ester groups, possible lactonization, and induced unsaturated groups in the backbone of all materials.

Samples on Supporting Ground

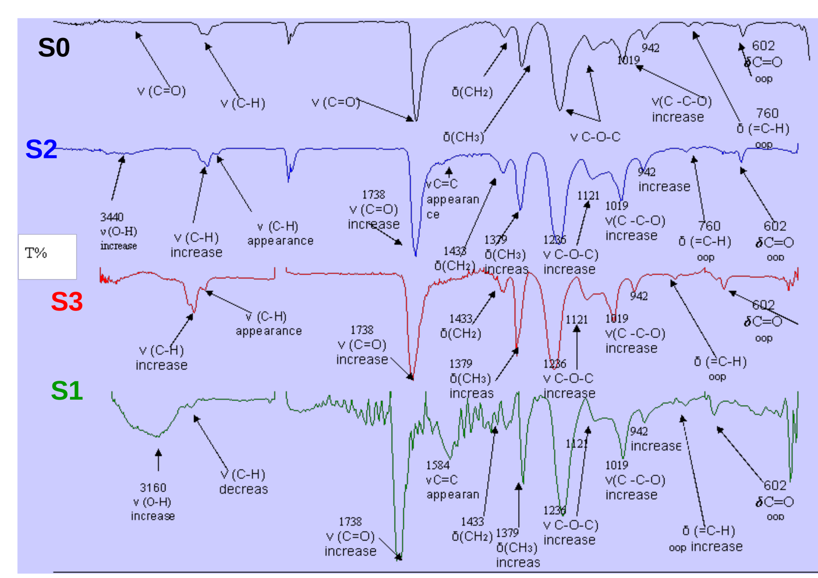
Samples of acrylate 1 and 2 and vinyl 1 were film-cast on glass substrate and were accordingly subjected to artificial ageing: (1) thermal (oven) at 50° C for ten months, (2) humidity (95% RH) for seven months and (3) UV lamp for ten months



Acrylate 1 on supporting ground: H0 initial; H1 heating (oven) at 50° C; H2 humidity (95% RH) and H3 UV lamp



Acrylate 2 on supporting ground: P0 initial; P1 heating (oven) at 50° C; P2 humidity (95% RH) and P3 UV lamp



Vinyl 1 on supporting ground: S0 Initial; S1 heating (oven) at 50° C; S2 humidity (95% RH) and S3 UV lamp

Summary of FTIR Results of Resins in Consolidated Support

The resins under investigation showed different behavior in consolidated supports because of the fact that these behave like a fairly complex material. The support material (basically inorganic aluminum silicates and calcium carbonate) works as a convenient host to possible hydrolytic and thermal reactions, while light penetration is severely reduced. Small reduction of esters was the effect of moisture in acrylic resins (no effect on the vinyl resin). Thermal exposure had a much more severe effect: formation of hydroxyl groups and significant unsaturation in both acrylic and the vinyl resins was observed, with parallel reduction of esters in the case of acrylic materials only. Finally, photochemical exposure induced slight unsaturation in the case of acrylic materials.

CONCLUSIONS

The resins under investigation showed different behavior in consolidated supports because of the fact that these behave like a fairly complex material. The support material (basically aluminum silicates and calcium carbonate) works as a convenient host to hydrolytic and thermal reactions, while light penetration is severely reduced. Small reduction of esters was the effect of moisture in acrylic resins (no effect on the vinyl resin).

Thermal exposure had a much more severe effect: formation of hydroxyl groups and significant amount of C=C double bonds in both acrylic and vinyl resins, with parallel reduction of esters in the case of acrylic materials only.

Finally, photochemical exposure induced slight unsaturation (i.e. formation of C=C double bonds) in the case of acrylic materials.

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