

The Institute for the Protection of Cultural Heritage of Slovenia  
Conservation Centre  
Restoration centre

# IDENTIFICATION OF PLASTIC MATERIALS IN MUSEUM COLLECTIONS WITH INFRARED SPECTROSCOPY

---

Dr. Andreja Padovnik

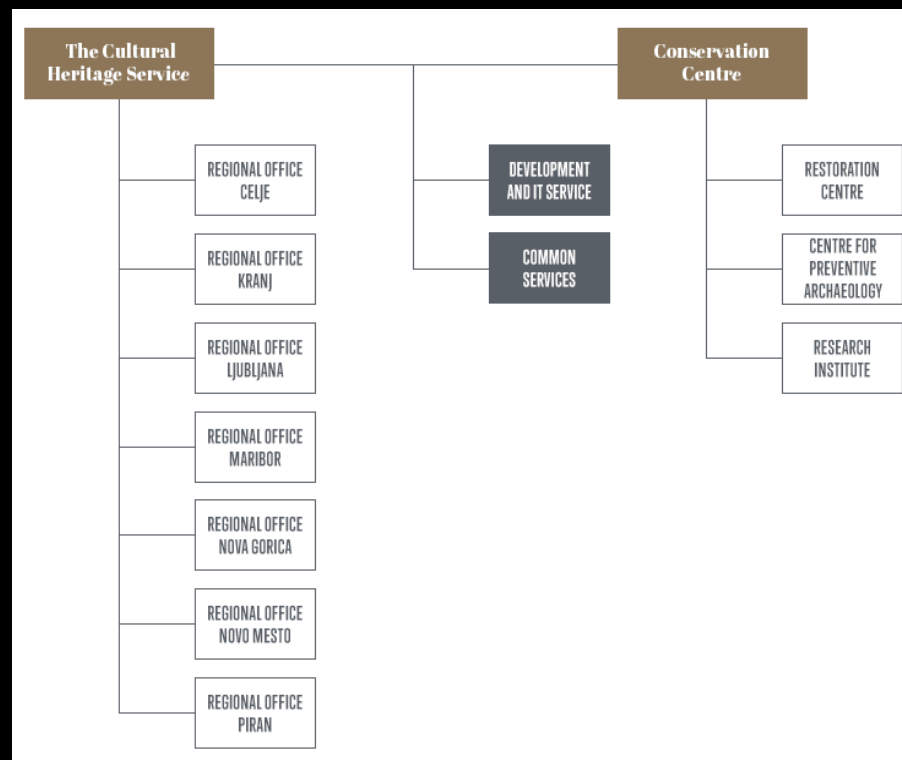
Plastics: Trash or Treasure?  
MAO, Ljubljana

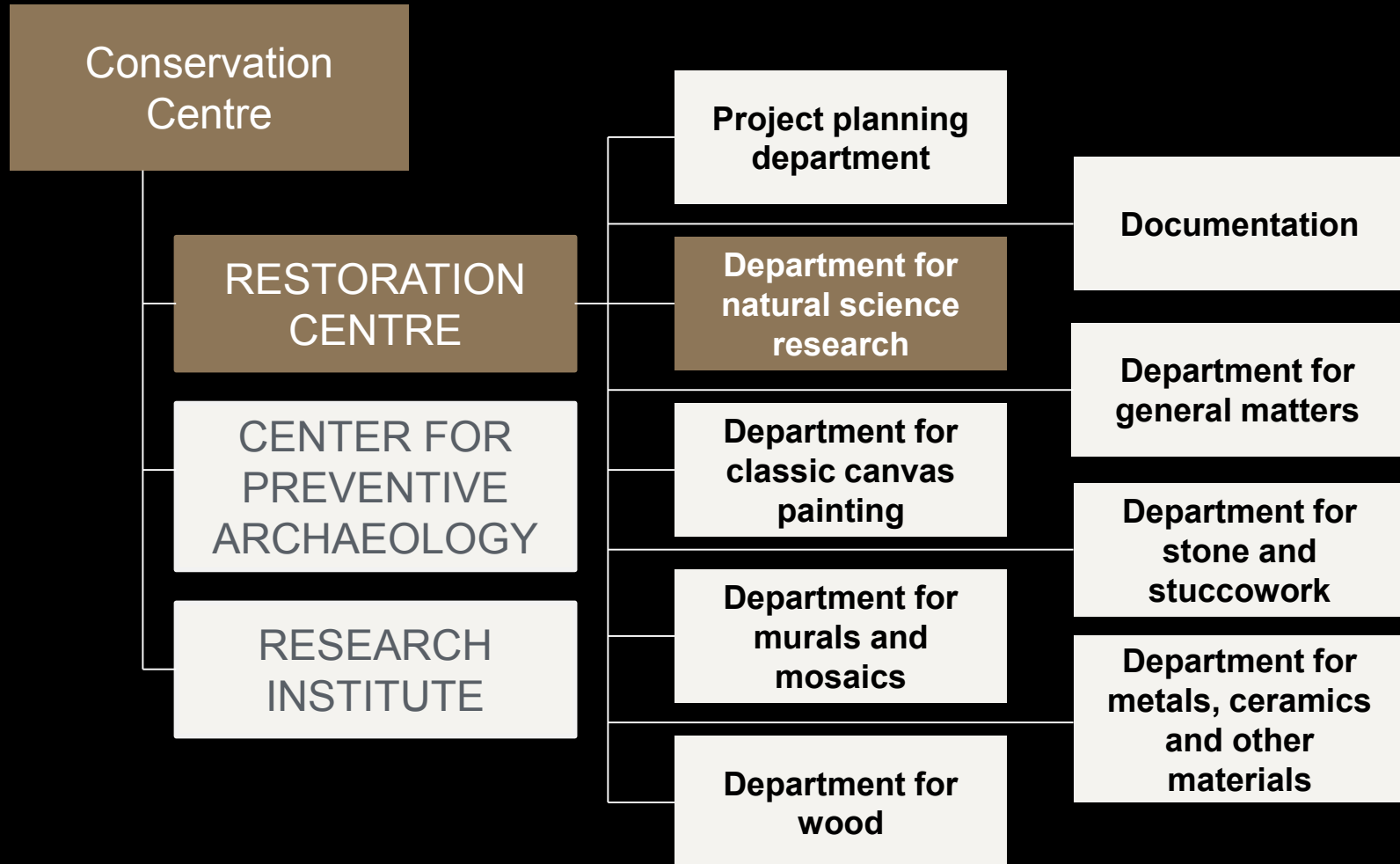
Ljubljana, 13 March 2017

# Institute for the Protection of Cultural Heritage of Slovenia

Institute for the Protection of Cultural Heritage of Slovenia is a public institute that carries out professional and administrative tasks with regard to the preservation of immovable and corresponding movable property and intangible cultural heritage.

The institute is composed of two main organizational units:  
**Cultural Heritage Service**  
and **Conservation Centre**.



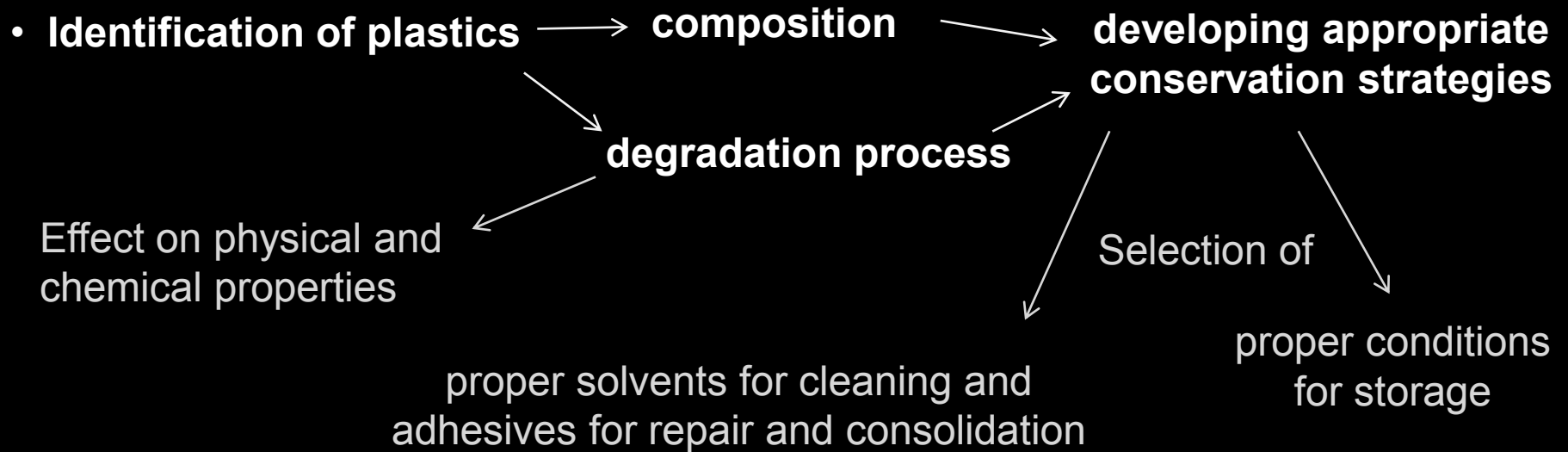


## PLASTIC MATERIALS

- **Plastics are polymer-based materials**
  - modified with additives
  - shaped to stable form
- **After 1839** → Development of semi-synthetic plastics
- **After 1907** → Development of synthetic plastics (Bakelite)
- **50 different groups of synthetic polymers** → around 60 000 plastic formulations (1000 different additives)

# IDENTIFICATION OF PLASTICS IN COLLECTIONS

- Identification of polymers is a complex process

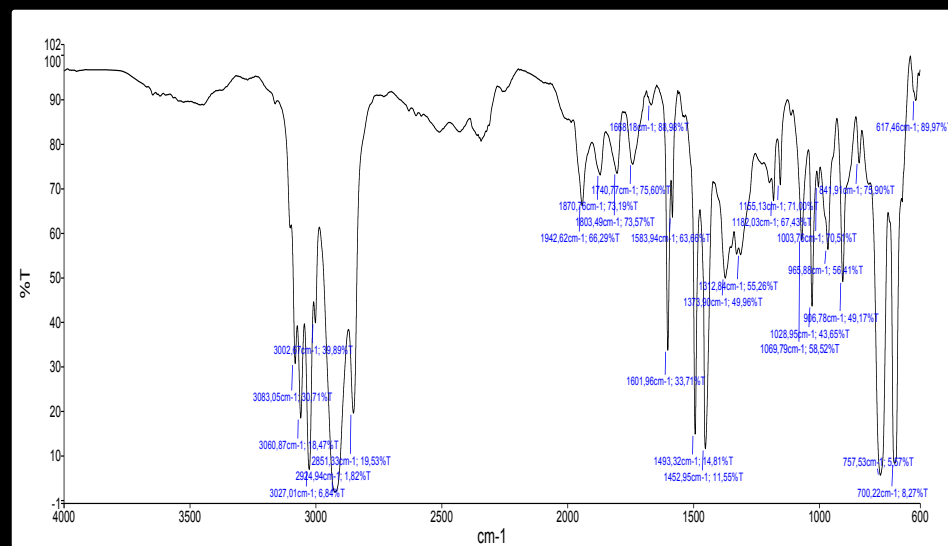
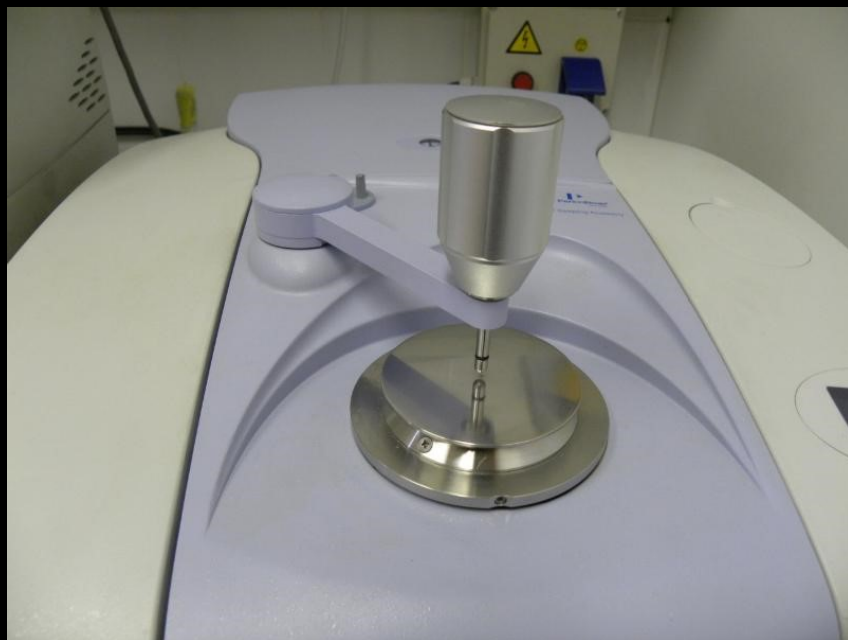


## PLASTICS IDENTIFICATION TECHNIQUES

- **Simple non-destructive identification techniques (appearance, odour)**
- **Simple destructive identification techniques (density, hardness, effect of heat, solubility etc.)**
- **Spot tests for identifying polymers or their components (tests for cellulose nitrate, cellulose acetate, polyamides etc.)**
- **Instrumental techniques to identify plastics (FTIR and RAMAN spectroscopy, Pyrolysis gas chromatography-mass spectrometry, EDS, XRF etc.)**

## Fourier transform infrared (FTIR) spectroscopy

- Fourier transform infrared spectroscopy with a diamond ATR crystal (Attenuated Total Reflection FTIR (ATR-FTIR)) has been used for the identification of polymers
- Identification of the polymers, fillers and plasticizers
- Destructive technique



# IDENTIFICATION OF PLASTIC OBJECTS





## ATA 12 automatic telephone, Iskra, 1956



- Casing: **Phenol-formaldehyde (Bakelite)**

Developed: 1907

Degradation: relatively stable but colour darkens by exposure to light, green became brown, became dull

- Cables: **Polyvinyl chloride (PVC)** and calcium carbonate as filler

Developed: 1927

wide use from 1940s

Degradation: yellowing and darkening; migration of additives to the surface creating either a bloom or sticky surface, which may lead to embrittlement.

## Componibili Square Storage Units, Anna Castelli, Kartell, 1965



- **Acrylonitrile butadiene styrene (ABS)**

Developed: 1948

Degradation: relatively stable but with a tendency to yellow

- Casters: **Polyethylene (PE)**

Developed: 1932

Degradation: yellows, stiffens and embrittles

## II electric drill, Albert Kastelec, Iskra, 1966



- Casing: **Polyformaldehyde (POM)**  
Developed: 1957  
Degradation: stable
- Cable: **Polyvinyl chloride (PVC) and calcium carbonate as filler**  
Developed: 1927  
wide use from 1940s

Degradation: yellowing and darkening;  
migration of additives to the surface creating  
either a bloom or sticky surface, which may  
lead to embrittlement.

## Rattle, Sergio Gobbo, Mehanotehnika, before 1979



- Styrene butadiene rubber (SBR)

Developed: during World War II

Degradation: relatively stable but with a tendency to yellow, photo-oxidation increases stiffening



## Žaba trash bin, Saša J. Mächtig, Elan (Imgrad?), 1973



- **Polyester**

Developed: 1941

Degradation: yellows, softens on heat (50-70°C), photo-oxidation causes discolouration

## Coat hanger, Karim Rashid, Normann, 2002



- **Styrene acrylonitrile (SAN)**

Developed: 1940

Degradation: relatively stable but with a tendency to yellow, photo-oxidation increases stiffening

## CONCLUSION

- **Plastic objects are becoming integral parts of cultural heritage.**
- **Often these polymers are less studied and their chemical decomposition has not yet been fully elucidated.**
- **Identifying the type of plastic is often challenging because plastics are available in a wide range of formulations where base polymers are mixed with organic and inorganic additives.**
- **It is necessary to understand the composition of plastic in order to set up proper conditions for storage and conservation of objects, because of their susceptibility to various environmental impacts (air, moisture, light, heat).**