Physical and chemical properties of fossil resins from world deposits

Paweł Stach

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ABSTRACT

In coal geology, fossil resins are classified as solid fossil fuels (caustobiolites) and as liptobiolite coals (liptobiolites) genetically. They are natural exudates of deciduous and coniferous trees, whose production in their secretory tissues (resin-derived cells) was initiated by internal (mechanical deformation, parasite activity, etc.) or external (volcanic phenomena, etc.) factors. The fossil resins are called a window into the past due to their unique physical and chemical properties that reflect geological history of Earth. Animal and plant remains entombed in fossil resins preserved their morphology over millions of years. These remains are the record of organism's evolution from prehistoric to present time. Thus, detailed structural studies, both chemical and physical, accompanied with petrological and microbiological investigations are frequently applied in order to reveal a botanical source of the fossils, environmental, geological and climate conditions of resin deposition. Likewise, revealing of resin's transformation pathways from burial to present fossil form, degree of resin fossilization and maturation is also possible based on results of structural studies. Knowledge on resin's transformation pathways in chemical structure from burial to presents form is also helpful in establishing of fossil age and its botanical source in the case when no microorganism remains are entombed in investigated specimen.

Over the past thirty years, significant progress has been achieved in understanding the relation between formation mechanisms, botanical source and physico-chemical properties of fossil resins, mainly due to advancement in electronics and informatics applied in analytical methods (FT-IR, FT-RS, FS, NMR, GC-MS, TGA, DSC) as well as development of various analytical techniques such as, for example, attenuated total reflectance (ATR) in FT-IR, temperature programmed pyrolysis in gas chromatography.

The aim of the study presented in this PhD dissertation, was further enhancement of the knowledge on fossil resins. For this purpose, specimens from 26 different locations in the world were investigated by various analytical methods. Those specimens were characterized by different age, botanical source, physico-chemical properties, burial and formation, environmental, climate, and geological condition. It was found that the physical and chemical properties of fossil resins are mostly influenced by the environmental conditions. The most important factor was elevated temperature during the fire that induced resins secretion but also affected chemical composition of resins. Fire may be induced by volcanism or climate events. Presence of iron minerals may also affect the physico-chemical properties of the fossils. Hot circulating fluids in deposits may accelerate transformation of the resins, increase of maturation degree and fossilization depends on deposits condition. However, it has been found that some compounds in the structure remain unchanged and can be used as biomarker of botanical origin of the resin. Some of compounds may be used for calculation of the resin age; however, this

requires more studies on large number of specimens. The results of thermal properties revealed amorphous, glass-like polymeric structure of the resins with strong structural stress likely caused by oxidation (aging), pressure or/and heat. Application of Temperature Modulated Differential Scanning Calorimetry allow to separate glass transition from relaxation enthalpy of the material.