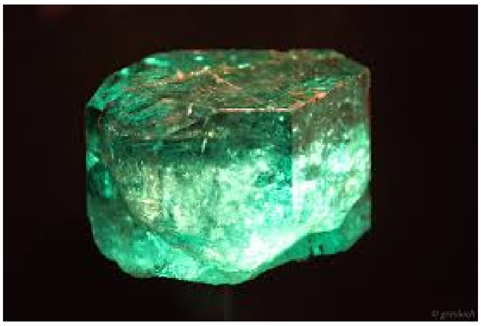
Spectroscopic Methodology for the Differentiation of Natural from Synthetic Emeralds

Italian researchers from the Department of Earth and Environmental Science at the University of Pavia, and the Gemological Institute of Valenza released their study of the characteristics of natural and synthetic emeralds using the AvaSpec-ULS2048 Spectrometer for broadband reflectance measurements (400-1000 nm) and offer their methodology for the classification of emeralds.

Spectroscopy in Gemology



The use of spectroscopy in the study of gems and minerals began not long after Isaac Newton first experimented with the separation of the sun's light into its component colors when split by a prism. By the mid-1800s, scientists were mapping the solar spectrum and beginning to identify absorption spectra for many common elements in gemstones.

Today, the technology to create synthetic gemstones taxes the ability of the gem market to classify and identify natural versus synthetic stones, identify treatments applied to stones, and in some cases, identify a stone's place of origin. The market is increasingly using photonics technologies to answer the demands of the gem and fine jewelry industry.

Natural Emerald Characteristics

Emeralds are a gemstone in the beryl family of minerals, with a characteristic deep green color due to the presence of chromium and iron. They are considered a type III gem due the ubiquitous presence of inclusions and surface breaking fissures. Because of these surface fissures, most commercially available emeralds are oil treated with cedar oil which has a similar refractive index.

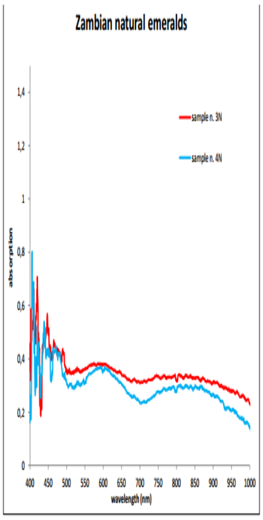
Emeralds can be found all over the world. They were mined in ancient Egypt circa 1500 BCE as well as in India and Austria as early as the 14th Century. Today, some of the largest areas for emerald production are Colombia, Zambia, and Brazil.

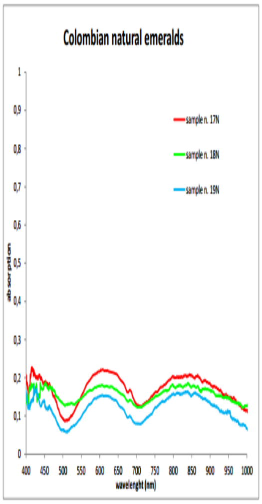
Creating Synthetic Emeralds

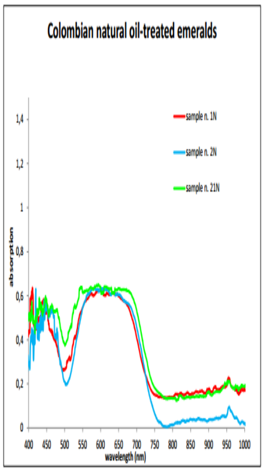
The popularity and mystique of the emerald have lead to this stone being one of the most frequently imitated gems. Synthetic stones were first introduced in the late 1800s, and the first artificially produced emeralds large enough for gem cutting were produced in the 1930s.

There are two principle methods for creating synthetic emeralds, flux-fusion and hydrothermal growth. The flux-fusion method is one of the oldest known methods for producing lab-created emeralds. It employs a heated solution of minerals, or flux, that forms crystals when cooled. This method for creating emeralds is painstakingly long, with suitable crystals requiring up to a year to grow. The similarly time-consuming hydrothermal method was introduced in the 1960s and involves the use of heat and pressure to mimic conditions produced in the Earth's crust.

Since the 1990's, new and increasingly sophisticated synthetic gems have been introduced that even more closely mimic the inclusions and other physical characteristics of natural emeralds. This makes reliable identification and classification by reputable gem traders that much more important to the market.







Synthetic Gems in the Marketplace

Synthetic gems share virtually all of the physical, chemical and optical characteristics as their natural counterparts, and are indistinguishable to the naked eye. Because they can be virtually created to order, however, stones of large and exceptional quality are simply not as rare among synthetic stones.

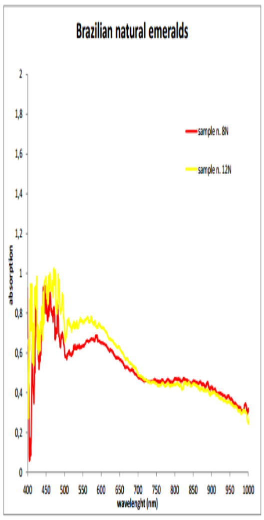
The Federal Trade Commission regulates the sale and marketing of synthetic gems, requiring disclosure of a gem's composition and origin. Additionally, the American Gem Trade Association (AGTA) and International gem trade associations provide guidelines and regulations to their members regarding the disclosure of a gem's synthetic origin at the time of sale.

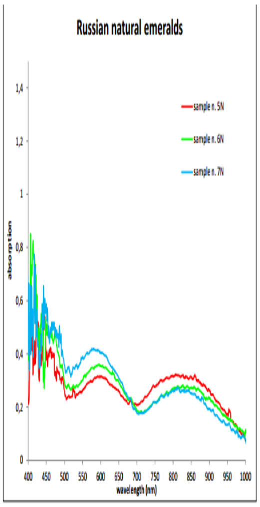
Using Visible/ Near-Infrared Spectroscopy for Identification

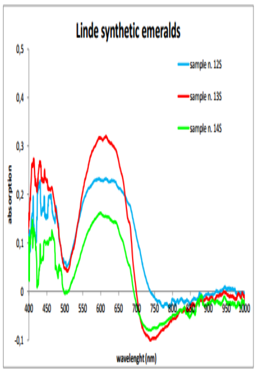
The Italian researchers worked with a selection of 19 natural and 22 synthetic faceted gems. The refractive indexes of the natural gems ranged from 1.571 to 1.598, while the synthetic gems had refractive indexes between 1.560 and 1.580.

The distinctive green color of emeralds is produced by the presence of Chromium and Iron. All of the samples displayed broad absorption bands near 430 nm and 600 nm with peaks at around 476, 680 and 683 nm attributable to chromium ions. The contribution of Iron produces typical spectral lines at 810 nm and 465 nm

By grouping samples by origin for natural stones and by process for synthetic stones, the reflectance spectra for each group showed distinct characteristics, however, that when combined with other typical gem analysis methods should reliably allow for the identification discrimination of natural from synthetic stones. (See figures.)



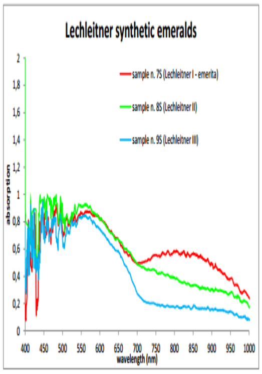


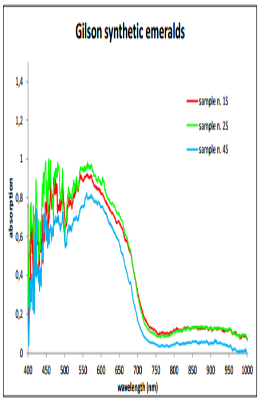


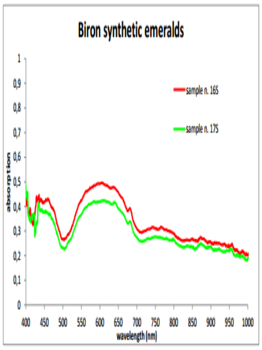
Advantages of Broadband Spectra Analysis

The biggest advantages of this spectroscopic method for gem analysis are the ease of sample preparation and the speed of spectra acquisition. Broadband spectroscopic analysis can take place at room temperature on cut stones and the warming effect of incident light protects the stone from damage from thermal cycling. Spectral data can be acquired in seconds and this method has been tested under typical laboratory conditions.

The presence of noise at low wavelengths (400-500 nm), especially prevalent among the synthetic gems, can be mitigated with the use of ultra-low noise spectrometers like the AvaSpec-ULS2048 which provides great signal to noise performance (200:1) and fast data acquisition (1.1 ms/scan).







Spectroscopy Applications in Gemology

In addition to synthetic gem identification, spectroscopy is also used to recognize gem treatments or to identify the origin of stones that might come from conflict zones. In addition to the AvaSpec-ULS2048L spectrometer, a typical configuration for gemological applications also includes an integrating sphere such as the AvaSphere-50-LS-Hal with integrated halogen light source or the AvaLight-Hal-Mini halogen lamp light source and fiber optic reflection probe. Some spectroscopy applications for gemology favor Raman spectroscopic measurements and Avantes offers our AvaRaman integrated Raman systems for 785 and 532 nm Raman as well as a variety of thermo-electrically cooled spectrometer options which can be configured for any visible wavelength.