The multidisciplinary field of astrobiology has grown rapidly in recent years. The major goals of research in the field have been the search for habitable environments both within and outside our solar system, the search for evidence of prebiotic chemistry and life on Mars and other bodies in our solar system, laboratory and field research into the origins and early evolution of life on Earth, and studies of the potential for life to adapt to challenges on Earth and in space. NASA and ESA are heavily focused on a number of upcoming exploratory missions (e.g., the Mars Science Laboratory, with its planned launch in the fall 2011; ExoMars 2018; and the follow-up Mars Sample Return missions beyond 2020). A Raman spectrometer is now being miniaturized for the ExoMars Rover Instrument Suite. This Raman instrument is expected to be used to identify organic compounds and mineral products that could be related to signatures of life, as well as provide a general mineralogical overview, especially those minerals produced by water-related processes. This thesis describes the results of laboratory investigation into the feasibility of Raman spectroscopy to detect different types of biomarkers (pigments, carboxylic acids, and aminoacids) first mixed in the mineral matrices and then covered by UV-transparent crystals of different thicknesses. Experiments were performed using near infrared 785 nm and visible 514 nm excitation wavelengths sources. Another goal of this thesis has been to grow model crystals containing organic compounds in different concentration levels embedded within fluid inclusions, thereby developing “mineralogical standards” suitable for testing via non-destructive micro-Raman spectroscopy. Raman spectroscopy has proven able to detect different biomolecules, not only those which are dispersed in mineral matrices and but also those which are dissolved and embedded in fluid inclusions non-destructively, and furthermore without any sample preparation, in the submicrometer range, in short measurement times, and in relatively low concentrations.