Highly stable zeolite HY/polypyrrole composite material was successfully fabricated by applying in-situ chemical polymerization approach. The functional properties of the prepared zeolite HY particles/polypyrrole were systematically inspected using XRD and FT-IR characterization techniques. Thermal stability and optical properties were consistently studied using TGA and UV–Vis spectroscopy techniques. The value of band gap energy (E_g) of the produced zeolite HY/polypyrrole nanocomposite was lower than the values of its individual components. Cyclic voltammetry studies concluded that HY/polypyrrole electrode material with mass ratio ~ 0.4 prepared at cold polymerization conditions ~ 0 °C exhibited the highest values of specific capacitance ~ 310 $F\ g^{-1}$ and ionic conductivity ~ 1.7 $S\ cm^{-1}$. The fabricated zeolite HY/polypyrrole composite material at 0 °C revealed a capacitance retention ~ 93.4%, while the other composite prepared at 25 °C possessed a capacitance retention ~ 72.4% after 500 charge/discharge cycles. The electrochemical impedance spectroscopy (EIS) measurement for the optimized composite electrode materials confirmed the cyclic stability after long term cycling of about 5000 cycles as a result of higher ionic conductivity between active material and ionic species than that value before cycling