The superconducting transition temperature ($T_c$) of tetragonal Fe$_{1+\delta}$Se can be enhanced from 8.5 K to 44 K by chemical structure modification resulting in significant increase of [Fe$_2$Se$_2$]-interlayer separation: from 5.5 Å in native Fe$_{1+\delta}$Se to > 7 Å in K$_x$Fe$_{1-y}$Se and to > 9 Å in Li$_{1-x}$Fe$_x$(OH)Fe$_{1-y}$Se. Structure modification is achieved by the shift of the [Fe$_2$Se$_2$]-slabs and filling the interlayer space by solvated lithium and iron cations or by large alkaline cations like K. We report the application of electrochemical approach to modification of Fe$_{1+\delta}$Se superconducting properties. In contrast to chemical way the electrochemical approach allows to insert small amount of non-solvated Li$^+$ into Fe$_{1+\delta}$Se structure keeping the native structure and [Fe$_2$Se$_2$]-layers arrangement. The amount of intercalated lithium is extremely small (about 0.07 Li$^+$ per f.u), however, caused slight change of carrier concentration results in enhancement of $T_c$ up to $\sim$ 44 K. The obtained results provide the opportunity to better understand the mechanism of superconductivity in Fe-based superconductors and open new possibilities for $T_c$-enhancement.

Keywords: superconductivity, iron selenide, Li-ion intercalation