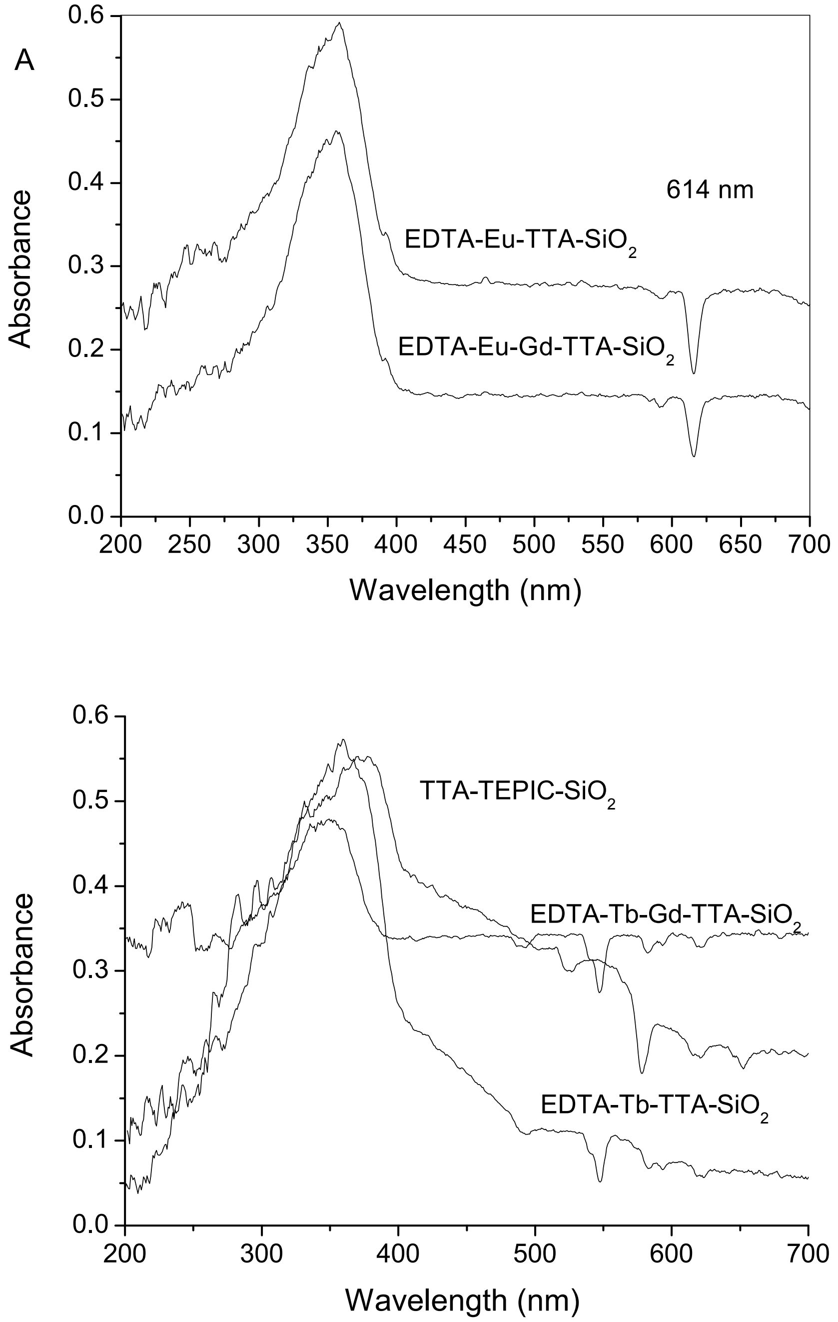

Figure S1 Diffuse reflectivity spectra of (A) of europium bifunctional hybrids and (B) of terbium bifunctional hybrids

The calculation of different parameters for the luminescence quantum efficiency

A_r can be obtained by summing over the radiative rates A_{0J} for each $^5D_0 \rightarrow {}^7F_J$ (J = 0–2) transitions of Eu^{3+}:

$$A_{rad} = \sum A_{0J} = A_{00} + A_{01} + A_{02} \quad (1)$$

Since the branching ratio for the $^5D_0 \rightarrow {}^7F_{3,4,5,6}$ transitions are too weak to be detected experimentally, so they can be neglected and their influence can also be ignored in the depopulation of the $^5D_0$ excited state. The magnetic dipole $^5D_0 \rightarrow {}^7F_1$ is considered as an internal reference for its independence of the chemical environments around Eu^{3+} and A_{0J}, the experimental coefficients of spontaneous emission, are calculated according to the equation.

$$A_{0J} = A_{01}(I_{0J}/I_{01})(\upsilon_{01}/\upsilon_{0J}) \quad (2)$$

Here υ_{0J} refers to the energy barycenter (J = 0, 1, 2), which can be determined as the reciprocal of the wavelength where the emission peaks of Eu^{3+}'s $^5D_0 \rightarrow {}^7F_J$ emission transitions. A_{01}, the Einstein's coefficient of spontaneous emission ($^5D_0 \rightarrow {}^7F_1$), can be determined to be 50 s^{-1} approximately ($A_{01} = n^3 A_{01}$ (vacuum)) in vacuum.

Since the lifetime and the I_{02}/I_{01} (red/orange ratio) are the two mainly factors to determine the value η, so the longer lifetimes and bigger red/orange ratio, the higher the quantum efficiency. The relation among the radiative (A_r), nonradiative (A_{nr}) transition rates and lifetime (τ) can be described as the following equation

$$\tau_{exp} = (A_r + A_{nr})^{-1} \quad (3)$$

According to the radiative transition rate constant and experimental luminescence lifetime, the quantum efficiency can be calculated from the following equation:

$$\tau = A_r \tau_{exp} \quad (4)$$