Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

Supporting Information:

Highly Luminescent Flexible Amino-Functionalized Graphene Quantum Dots@Cellulose Nanofiber-Clay Hybrids for White Light-Emitting Diodes

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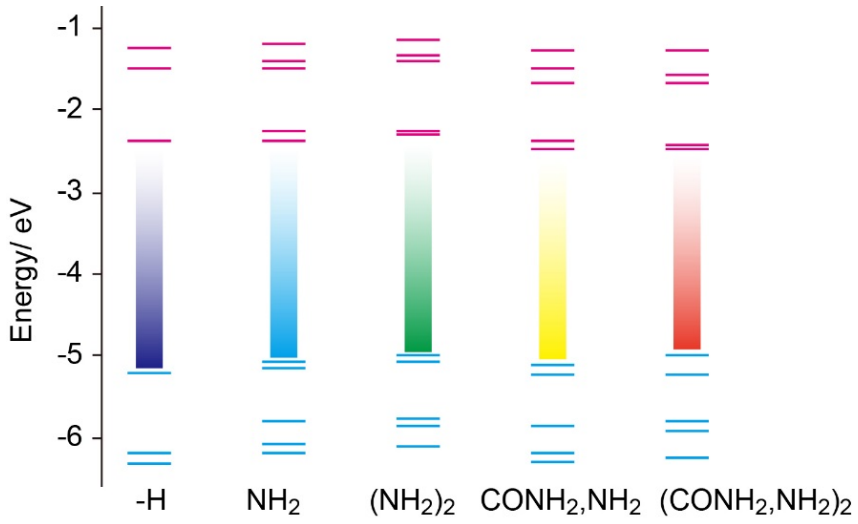


Figure S1. Comparison of energy levels and HOMO–LUMO gaps in armchair-edged $C_{54}H_{18}$ with different functional groups.

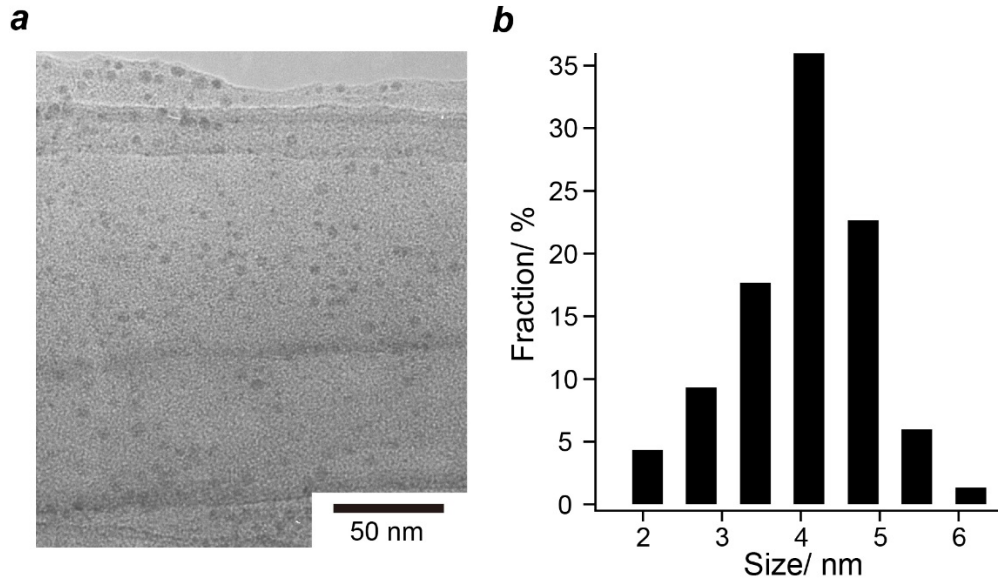


Figure S2. a) Bright-field TEM image of green-emitting afGQDs. b) The size distributions of green-emitting af-GQDs.

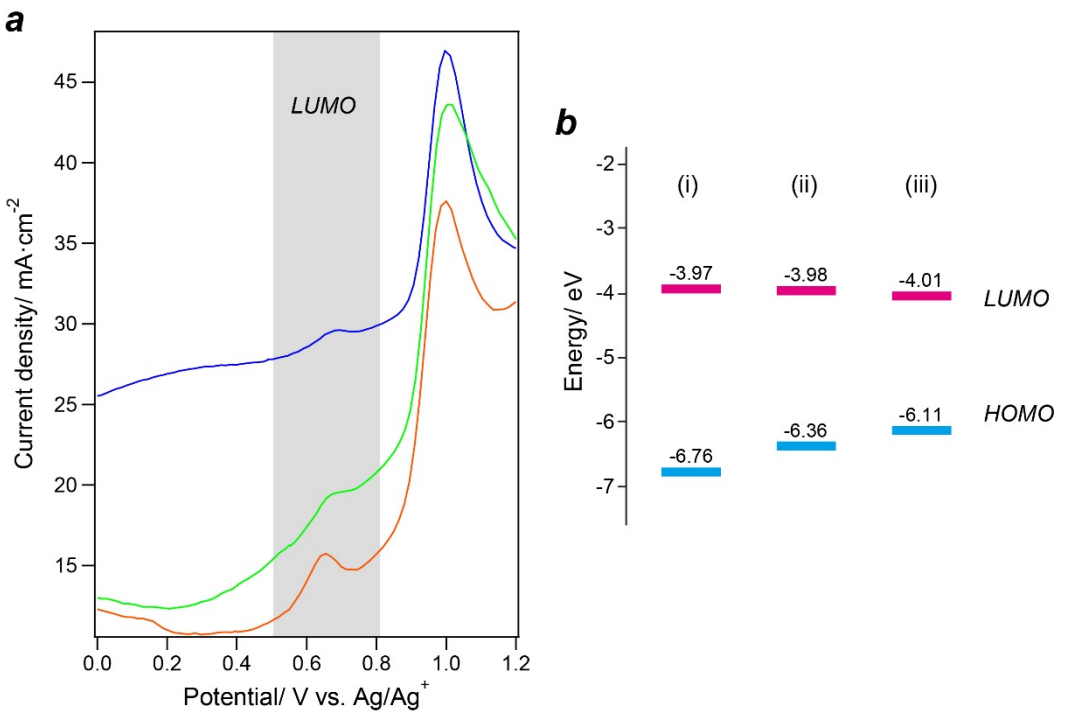
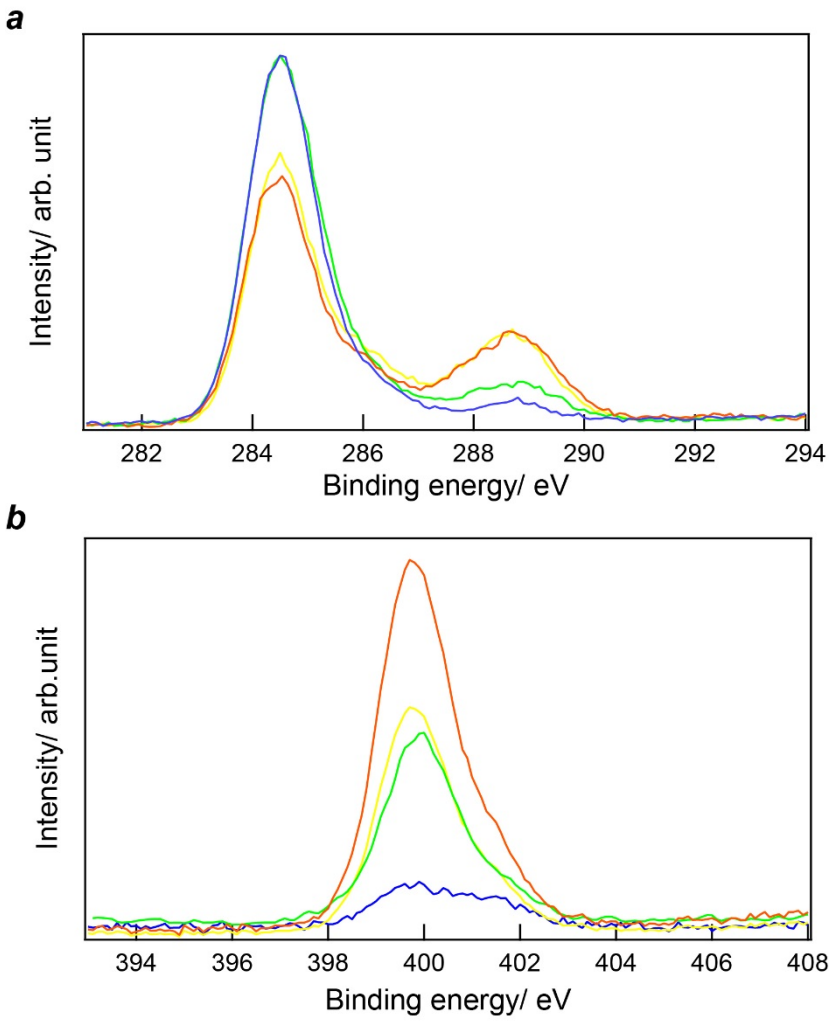


Figure S3. a) CV curves (anodic scan) of afGQDs: blue line, blue-emitting afGQDs; green line, green-emitting afGQDs; orange-line, orange-emitting afGQDs. The LUMO

levels can be calculated by the following empirical equation: $LUMO = -e(E_{red} + 4.4)$ eV.

b) Energy level diagram for afGQDs: (i), blue-emitting afGQDs; (ii), green-emitting afGQDs; (iii), orange-emitting afGQDs. The HOMO levels were determined by subtracting excitation energy from LUMO energy, where the excitation energy was estimated by the direct conversion of emission peak into eV.



c

	I	II	III	IV
C/N ratio	26.8	8.1	7.8	4.3

Figure S4. C1s (a) and N 1s (b) X-ray photoelectron spectra for afGQDs; blue line: blue-emitting afGQDs, green line: green-emitting afGQDs, yellow line: yellow-emitting afGQDs, and orange line: orange-emitting afGQDs. c) The table summarises the C/N

ratios calculated from the atomic concentrations: I, blue-emitting afGQDs; II, green-emitting afGQDs; III, yellow-emitting afGQDs; IV, orange-emitting afGQDs.

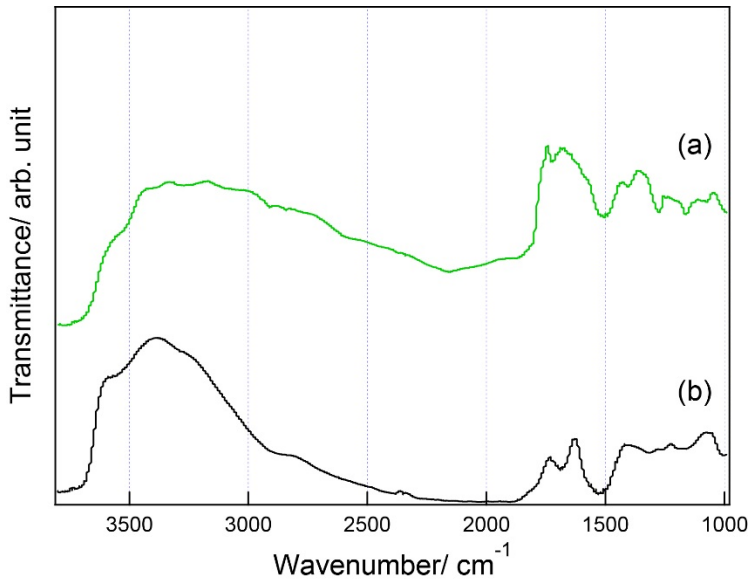


Figure S5. Comparison of FT-IR spectra: (a) green-emitting afGQDs, (b) starting OGSs. New peaks at 1243, 1617, and 3300–3600 cm^{-1} appeared after the amino-hydrothermal treatment. These peaks were assigned, respectively, to C-N in-plane, N-H out-of-plane, and N-H in-plane stretching of the amine groups. Additionally, characteristic amide–carbonyl (–NH-CO–) stretching vibration was observed at 1650 cm^{-1}, which implies the formation of amide groups through interactions with the carboxylic groups as Lewis acids.

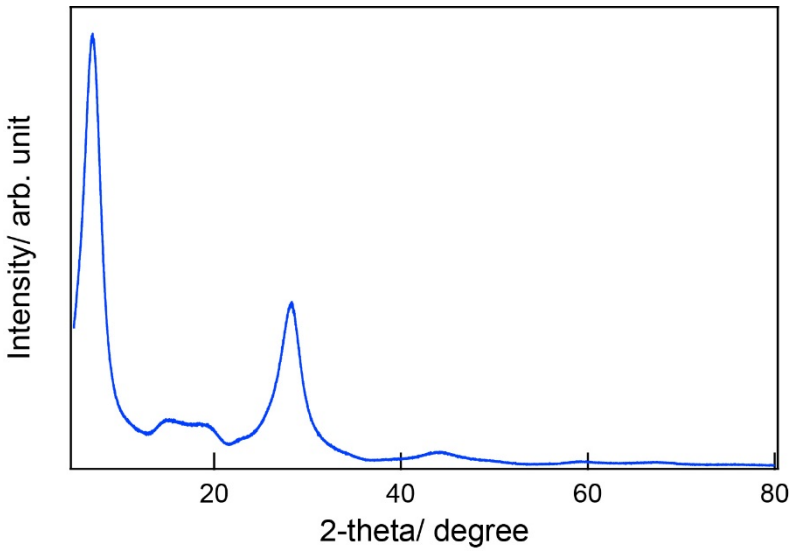


Figure S6. XRD pattern from green-emitting afGQDs@CNF-clay film.

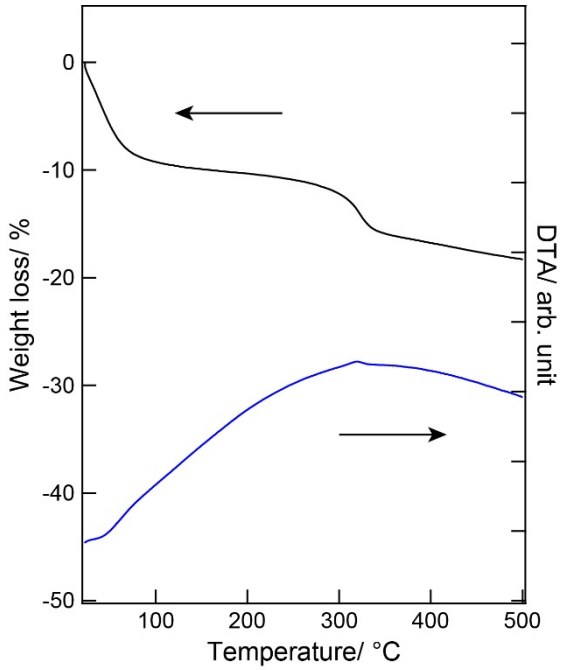


Figure S7. TG-DTA curve with the weight loss and exo-endothermal reaction of the green-emitting afGQDs@CNF-clay film. Two stages of weight loss were apparent: (i) substantial weight loss attributable to the release of water molecules adsorbed on the clay (<100 °C) and (ii) thermal decomposition of the cellulose nanofiber (320 °C).

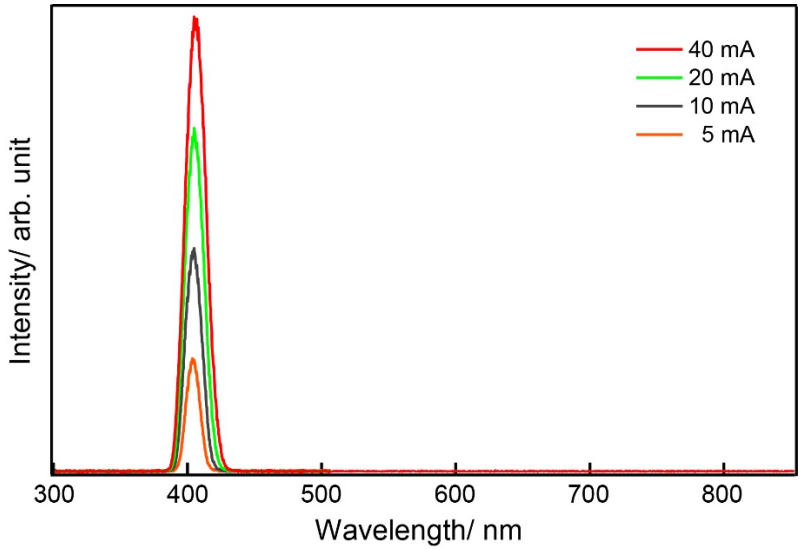


Figure S8. Luminescence spectra of blue LED with CNF-clay films without afGQDs under various forward currents.

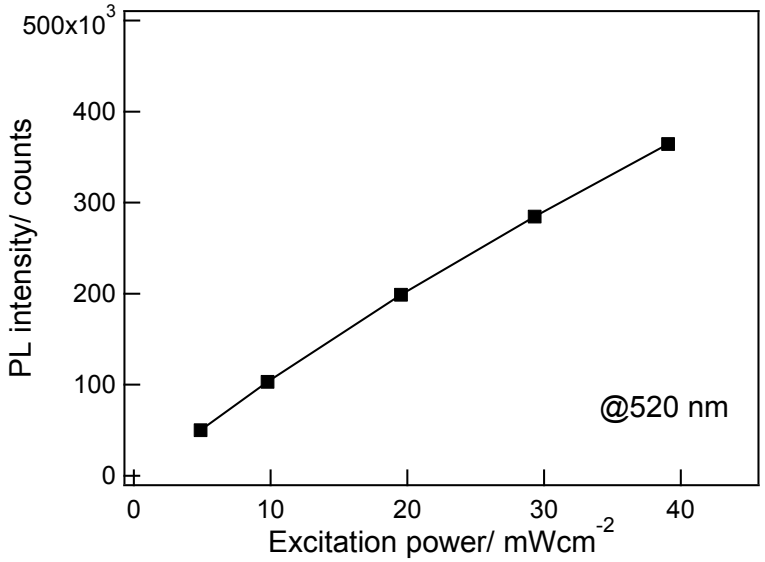


Figure S9. Excitation power dependence of PL intensity for green-emitting afGQDs@CNF-clay hybrids. The PL measurements were carried out using a 355 nm Nd:YAG laser and a high-sensitive photomultiplier tube detector at room temperature. The PL intensity increased linearly as the laser power was below 20 $mWcm^{-2}$ and then showed slight saturation at higher powers.