Kidney Guard: A Far-Red Chemiluminescent Probe Platform for Early and Point-of-Care Detection of Acute Kidney Injury

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Acute kidney injury (AKI) affects over 13.3 million people annually, yet early diagnosis remains difficult because renal damage often develops subclinically before overt dysfunction becomes apparent. This is particularly challenging for point-of-care testing, as current colorimetric and fluorescence-based assays often lack sufficient sensitivity for early-stage detection. Here, I present an ultrasensitive chemiluminescent probe Red-NAG, together with a portable diagnostic platform Kidney Guard for early AKI warning. Red-NAG integrates an N-acetyl-ß-D-glucosaminidase (NAG)-responsive moiety to a photoactivatable chemiluminophore through a self-immolative linker. Upon selective hydrolysis by urinary NAG, an established early biomarker of proximal tubular injury, the chemiluminophore is released and subsequently emits bright red chemiluminescence upon light activation. This sequential NAG-light response mechanism enables signal accumulation during enzyme hydrolysis, thereby significantly improving detection sensitivity. Red-NAG exhibited a 56-fold improvement in sensitivity over commercial probes, achieving a detection limit of 0.027 U/L, well below the clinical cutoff of 12 U/L, with excellent linearity from 0.5 to 300 U/L (R2 = 0.999). To translate this analytical performance into practical application, Kidney Guard allows direct urine analysis following a 25-min incubation period, with subsequent portable imaging performed using a Raspberry Pi-based camera system. A dedicated algorithm converts luminance values into quantitative NAG concentrations, and diagnostic results are transmitted to a smartphone. This integrated platform offers a promising approach for accessible early AKI screening and preventive monitoring.

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