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DESIGN AND DEVELOPMENT OF FLUORESCENT PROBE FOR SUGAR SENSING

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สุชาดา นาววงศ์ศรี : การออกแบบและพัฒนาฟลูออเรสเซนต์โพรบสำหรับการรับรู้ น้ำตาล. (DESIGN AND DEVELOPMENT OF FLUORESCENT PROBE FOR SUGAR SENSING) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: ผศ. ดร.บุษยรัตน์ ธรรมพัฒน์กิจ, 100 หน้า.

เป้าหมายของงานวิจัยนี้คือ การสังเคราะห์ฟลูออเรสเซนต์เซ็นเซอร์ Cum_B ที่ประกอบด้วยคูมารินเป็นหมู่ฟลูออโรฟอร์และกรดโบโรนิกเป็นหน่วยเกิดปฏิกิริยาและเซ็นเซอร์ NBDB_AuNPs ประกอบด้วยหมู่แนฟทาลิไมด์เป็นหมู่ฟลูออโรฟอร์ กรดโบโรนิกเป็นหน่วยเกิดปฏิกิริยากับน้ำตาลและหมู่ไดพามีนเป็นตัวเชื่อมระหว่างแนฟทาลิไมด์และกรดโบโรนิก ในช่วงแรกได้ศึกษาคุณสมบัติการเป็นเซ็นเซอร์ของ Cum_B เพื่อใช้ในการตรวจวัดน้ำตาล ในตัวทำละลายผสมของไดเมทิลซัลโฟลไซด์กับฟอสเฟตบัฟเฟอร์ที่ pH 7.4 โดยใช้เทคนิคฟลูออเรสเซนต์สเปกโตรโฟโตเมทรี พบว่าเซ็นเซอร์ Cum_B มีความจำเพาะเจาะจงกับน้ำตาลฟรุคโตสมากกว่าน้ำตาลชนิดอื่นๆ สืบเนื่องจากการลดลงของสัญญาณฟลูออเรสเซนต์ ด้วยกระบวนการ PET และพบว่าค่าคงที่การจับ ($\log K_s$) และขีดจำกัดต่ำสุดของการตรวจวัดของเซ็นเซอร์ Cum_B กับน้ำตาลฟรุคโตสเท่ากับ 3.6 และ 2.83 มิลลิโมลาร์ ตามลำดับ สำหรับเซ็นเซอร์ NBDB พบว่ามีการเปลี่ยนแปลงสัญญาณฟลูออเรสเซนต์น้อยมากและไม่มี ความจำเพาะเจาะจงกับน้ำตาลชนิดใดๆ เพื่อปรับปรุงความสามารถในการตรวจวัดน้ำตาลของเซ็นเซอร์นี้ จึงได้ดัดแปรเซ็นเซอร์ NBDB บนอนุภาคทองคำระดับนาโน (AuNPs) ทำให้เกิดการถ่ายโอนพลังงานจากเซ็นเซอร์ NBDB ไปยัง AuNPs ทำให้สัญญาณฟลูออเรสเซนต์ต่ำลง เมื่อ NBDB จับกับน้ำตาลฟรุคโตส ทำให้ NBD หลุดออกจาก AuNPs จะเกิดการยับยั้งการถ่ายโอนพลังงานทำให้เห็นสัญญาณฟลูออเรสเซนต์ของ NBD เพิ่มสูงขึ้นอย่างมาก จากหลักการนี้พบว่าสามารถตรวจวัดน้ำตาลฟรุคโตสได้อย่างจำเพาะเจาะจงและมีความไวสูง โดยมีค่าคงที่ในการตรวจวัดน้ำตาลฟรุคโตสด้วยค่า $\log K_s$ เท่ากับ 4.35 และขีดจำกัดต่ำสุดของการตรวจวัดเท่ากับ 1.50 มิลลิโมลาร์ ดังนั้น NBDB_AuNPs สามารถตรวจวัดน้ำตาลฟรุคโตสได้อย่างมีประสิทธิภาพมากกว่า Cum_B

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ลายมือชื่อนิสิต สุชาดา นาววงศ์ศรี

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An aim of this research is to synthesize the fluorescence sensors Cum_B consisting a coumarin as fluorophore and boronic acid as active site and sensor NBDB_AuNPs containing naphthalimide as fluorophore, boronic acid as binding site and dopamine as linker. Initially, the complexation properties of sensor Cum_B toward saccharides in DMSO: phosphate buffer pH 7.4 were investigated by fluorescence spectrophotometry. It was found that sensor Cum_B showed high selectivity with fructose over other saccharides under PET process and also the log Ks values and detection limit of Cum_B with fructose were 3.6 and 2.83 mM, respectively. For sensor NBDB, it showed a poor fluorescence change and no selectivity with all saccharides. To improve the sensing ability of this sensor, the fabrication of NBDB on AuNPs was performed to improve the significant change of fluorescence. This approach is based on the energy transfer from NBDB to AuNPs resulting in the fluorescence quenching. As anticipated, the suitable saccharides bind to boronic ester to separate NBD and AuNPs inducing fluorescence enhancement of NBD. As a result, fructose was found to induce a large fluorescence enhancement of NBDB_AuNPs system under the inhibition of the energy transfer process from NBDB to AuNPs. The sensor NBDB_AuNPs demonstrates more excellently sensing ability toward fructose than sensor Cum_B with log Ks values of 4.35 and detection limit of 1.50 mM for NBDB_AuNPs.

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LIST OF ABBREVIATIONS

$^1\text{H-NMR}$	Proton nuclear magnetic resonance
$^{13}\text{C-NMR}$	Carbon nuclear magnetic resonance
Hz	Hertz
J	Coupling constant
δ	Chemical shift
m/z	Mass per charge ratio
L	Litre
μ	Micro
μL	Microliter
μM	Micromolar
β	Beta
ppm	Part per million
rpm	Revolutions per minute
$^{\circ}\text{C}$	Degree Celsius
nm	Nanometer
equiv.	Equivalent
mmol	Millimole
M	Molar
Mg	Milligram
mL	Milliliter
s, d, t, m	Splitting patterns of $^1\text{H-NMR}$ (singlet, doublet, triplet, multiplet)
EA	Elemental Analysis



Anal. Calcd.	Analysis calculated
DMSO	Dimethylsulfoxide
CH ₂ Cl ₂	Dichloromethane
MEOH	Methanol
ICT	Intramolecular charge transfer
PET	Photoinduced electron transfer
K _s	Stability constant
AuNPs	Gold nanoparticles

