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PREPARATION AND CHARACTERIZATION OF MnO_2 DOPED IN
SODA LIME SILICATE GLASS SYSTEM

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A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR
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หัวข้อวิทยานิพนธ์	การเตรียมและการศึกษาผลของการเติมแมงกานีสลงในแก้วโซดาแลร์มซิลิเกต
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งานวิจัยนี้ได้ทำการเตรียมแก้วระบบโซดาไลม์ในอัตราส่วน $(65-x)\text{SiO}_2 : 25\text{Na}_2\text{O} : 10\text{CaO} : x\text{MnO}_2$ เมื่อ x มีค่าเป็น 0.0, 0.10, 0.20, 0.30, 0.40 and 0.50 เปอร์เซ็นต์โดยโมล ด้วยวิธีการหลอมและทำให้เย็นตัวลงอย่างรวดเร็ว จากนั้นทำการศึกษาคุณสมบัติทางแสงและทางกายภาพของแก้วที่ได้เตรียมขึ้น พบว่าค่าความหนาแน่นมีค่าเพิ่มมากขึ้นเมื่อเพิ่มความเข้มข้นของแมงกานีส ซึ่งเป็นผลจากการเจือ MnO_2 เข้าไปแทนที่ SiO_2 โดยมวลโมเลกุลของ MnO_2 มีค่ามากกว่า SiO_2 ค่าปริมาตรเชิงโมลของแก้วจะมีค่าลดลงเมื่อเพิ่มความเข้มข้นของแมงกานีส ทั้งนี้เนื่องมาจากเกิดการลดลงของช่องว่างในโครงสร้างแก้ว ทำให้โครงสร้างของแก้วมีการยึดเกาะกันแน่นมากขึ้น ในส่วนของค่าดัชนีหักเห ค่าคงตัวของไดอิเล็กทริก (dielectric constant) ค่าคงตัวของไดอิเล็กทริกเชิงแสง (optical dielectric constant) การหักเหเชิงโมล (molar refraction) และ ค่าการสูญเสียจากการสะท้อน (reflection loss) มีค่าเพิ่มมากขึ้นเมื่อเพิ่มความเข้มข้นของแมงกานีส จากนั้นทำการวัดสเปกตรัมการดูดกลืนแสงในช่วง 300 – 1,100 นาโนเมตร พบว่าเกิดพีคการดูดกลืนที่ความยาวคลื่น 495 นาโนเมตร ซึ่งเกิดจากการเปลี่ยนแปลงไอออนของแมงกานีสในระดับชั้นพลังงาน ${}^5\text{E}_g \rightarrow {}^5\text{T}_{2g}$ ส่งผลทำให้แก้วที่ทำการเจือสารแมงกานีสเกิดการเปลี่ยนสีจากใสไม่มีสีเป็นสีม่วงเข้ม

คำสำคัญ : แก้วโซดาไลม์ซิลิเกต / แมงกานีส / คุณสมบัติทางแสง / คุณสมบัติทางกายภาพ

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Abstract

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In this research, glass with a composition of (65-x)SiO₂ : 25Na₂O : 10CaO : xMnO₂ where x is 0.0, 0.10, 0.20, 0.30, 0.40 and 0.50 mol% was prepared by a normal melt-quenching technique. The physical and optical properties of glass samples were investigated. The results showed that the density increases with increasing MnO₂ concentration. It indicates that replacing SiO₂ with small amount of MnO₂ results in the increase of the average molecular weight of oxide ions in the glass because MnO₂ has higher relative molecular mass than that of SiO₂. The molar volume decreases with increasing MnO₂ concentration due to the decrease in the bond length or the inter-atomic spacing between the atoms. This may be attributed the increase in the stretching force constants of the bonds inside the glass network. The refractive index, dielectric constant, optical dielectric constant, molar refraction and reflection loss increases with increasing MnO₂ content. The optical absorption spectra of the glasses were measured in the wavelength range of 300-1,100 nm. The fundamental absorption edge of glasses was determined from the optical absorption spectra. The absorption band peaked at 495 nm was observed. This absorption band is assigned to a single allowed $^5E_g \rightarrow ^5T_{2g}$ transition which arises from the manganic (Mn³⁺) ions. The undoped glass sample was colorless while the MnO₂ doped glasses were purple.

Keywords: Soda Lime Silicate Glass / MnO₂ / Optical Properties / Physical Properties

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LIST OF ABBREVIATIONS AND SYMBOLS

A	Absorbance
BO	Bridging Oxygen Atom
D	Optical Density
d	Thickness of Sample
F	Field Strength
I_0	Intensities of Incident Radiation
I	Intensities of Transmitted Radiation
$M(n_0)$,	Refractive index-based Metallization Criterion
M_T	Molecular Weight
N	Number of polarizable ions per mole
NBOs	Non-Bridging Oxygens
N_L	Loschmidt number
n_d	Refractive index
R	Refractance
R_m	Molar refractivity
r_i	Inter Nuclear Distance
r_p	Polaron Radius
T	Temperature
T_g	Glass Transition Temperature
T_m	Melting Temperature
UV	Ultraviolet
VIS	Visible
V_M	Molar Volume
w_a	Weight of the Specimen in Air
w_b	Weight of the Specimen in Water
x_i	Mole Fraction
α	Absorption Coefficient
α_T	Thermal Expansion Coefficient
α_o^{2-}	Electronic Oxide Polarizability
α_m	Molar polarizability
ϵ_0	Absolute permittivity of the free space
ϵ	Electric permittivity of the medium
ϵ_s	Relative dielectric constant
v_d	Abbe Number
ρ	Density
λ	Wavelength
A	Optical Basicity
$A(n_0)$	Refractive index-based optical basicity
A_{th}	Theoretical optical basicity