شبكة المعلومات الجامعية

التوثيق الإلكتروني والميكروفيلم

بسم الله الرحمن الرحيم

HANAA ALY

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جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

قسم

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كليه العلوم – قسم الكيمياء

Studies on the nano spinel addition effect on zirconia properties

Thesis Submitted by:
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(M.Sc. Applied Chemistry 2015)

For the requirement of Ph.D. of Science in Chemistry
Under the supervision of

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President of Central Metallurgical Research and Development Institute (CMRDI)
to

Department of Chemistry
Faculty of Science - Ain Shams University

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كليه العلوم – قسم الكيمياء

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قَالَ تَعَالَىٰ: ﴿وَمَا تَكُونُ فِي شَأْنٍ وَمَا تَتْلُوا۟ مِنْهُ مِن قُرْءَانٍ
وَلَا تَعْمَلُونَ مِنْ عَمَلٍ إِلَّا كُنَّا عَلَيْكُمْ شُهُودًا إِذْ
تُفِيضُونَ فِيهِ ۚ وَمَا يَعْزُبُ عَن رَّبِّكَ مِن مِّثْقَالِ ذَرَّةٍ فِي
ٱلْأَرْضِ وَلَا فِي ٱلسَّمَآءِ وَلَآ أَصْغَرَ مِن ذَٰلِكَ وَلَآ أَكْبَرَ
إِلَّا فِي كِتَٰبٍ مُّبِينٍ ﴿٦١﴾

يونس: ٦١

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ABBREVIATIONS	2021

Symbol	Description
AR	Alumina rich spinel
ASTM	American standard testing material
ATZ	Alumina toughened zirconia
c-ZrO_2	Cubic zirconia
EBSD	Electron back-scattered diffraction
EDS	Energy dispersive spectroscopy
FESEM	Field emission scanning electron microscope
HV	Vickers hardness
LTD	Low temperature degradation
MA	Magnesium aluminate spinel
MR	Magnesium rich spinel
m-ZrO_2	Monoclinic zirconia
PSD	Particle size distribution
PSZ	Partially stabilized zirconia
SA6	Strontium hexa-aluminate
SOFC	Solid oxide fuel cell
SPS	Spark plasma sintering
TZP	Tetragonal zirconia polycrystals
t-ZrO_2	Tetragonal zirconia
XRD	X-ray diffraction
XRF	X-ray fluorescence
YSZ	Yttria stabilized zirconia
ZAR	Zirconia stabilized with alumina rich spinel
ZMA	Zirconia stabilized with spinel
ZMR	Zirconia stabilized with magnesia rich spinel
ZTA	Zirconia toughened alumina
ZTC	Zirconia toughened composites

Abstract

This study aimed to illustrate the effect of magnesium aluminate spinel (MA) addition on sintering, densification, stabilization behavior and mechanical properties of commercial monoclinic zirconia. Three different MA powders were prepared from magnesium and aluminum waste with MgO: Al_2O_3 molar ratios of 1:1, 2:1 and 1:2. Spinel (MA), magnesia rich spinel $MgO.MgAl_2O_4$ (MR) and alumina rich spinel Al_2O_3. $MgAl_2O_4$ (AR) powders were synthesized via co-precipitation method. Six different sets were prepared by mixing MA, MR and AR powders with different proportions of commercial m-ZrO_2 and Y_2O_3 where, the MA, MR and AR content ranged from 0 to 50 wt., % with the increment of 10 wt., %. The obtained powders were sintered using spark plasma sintering technique at different temperatures with a heating rate of 100 ºC /min, applied pressure of 40 Mpa and holding time of 30 min under vacuum. Regarding the stoichiometric composition, three different batch compositions have been prepared named as: (1) Zirconia-magnesia alumina spinel composites (ZMA), (2) Zirconia-magnesia rich spinel composites (ZMR) and (3) Zirconia-alumina rich spinel composites (ZAR). Full characterization of all zirconia-spinel composites in terms of phase transformation; microstructure, mechanical properties (e.g., hardness, compressive strength, and toughness) and aging phenomenon was performed. The results showed that, stoichiometric composition and sintering

temperature/time have a considerable effect on the microstructure of the prepared ceramic composites. ZMR composites showed moderate strength with improved sintering properties at relatively lower temperature. ZAR composites showed moderate strength, but with low sintering and densification properties. While, ZMA composites showed improved strength with moderate sintering and densification properties. All the investigated composites, except zirconia free spinel composite, showed high resistance to low temperature degradation, aging, in the moisture atmosphere, demonstrating its validity to be potentially applied for various medical and engineering applications.

Keywords

Magnesium aluminate spinel, Zirconia, Spark plasma sintering, Stabilization, Low temperature degradation, XRD, FESEM

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