Ain Shams University
Faculty of Science
Physics Department

Study of New Polymeric/Ilmenite Composites as Shields for Neutron Sources

A Thesis

Submitted to Ain Shams University for the degree of Doctor of Philosophy in Physics

By

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Approval of Faculty Council	**Approval of University Council**
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Thanks to Allah

The Merciful,

For my success in completing this work**.**

Dedication

For All My Loving Family;

My Father of the deceased and My Mother,

My Brothers and My Sister,

My Wife and My Sons; Anas and Malek

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Aim of work

The work aims to obtain a high-quality neutron radiation-shielding material that has characteristics of lightweight, cheap, and easy to prepare.

The attenuation parameters were evaluated experimental and calculated theoretically by MCNP5 simulation and the Win XCOM program for gamma-rays.

Abstract

This thesis is concerned with the investigation of the physical, thermomechanical, and radiation attenuation properties of some shielding materials. Selected shields of Acrylamide, Acrylic acid, and Polyvinyl Alcohol hydrogel composites were chosen to fulfill certain applications and are concerned for the present work. Both hydrogels (Acrylamide, Acrylic acid, and Polyvinyl Alcohol) were filled with ilmenite and as well as, boric acid for homogeneous shields. In general, polymeric substances are hydro carbonic substances which guarantee good neutron moderation and attenuation. Furthermore, ilmenite was employed for gamma-rays attenuation.

Any material used for shielding purposes should fulfill some design criterion which includes physical and thermomechanical proficiency beside their main role as nuclear radiations attenuator. Therefore, physical properties as density, water absorption, and porosity were tested. Also, thermomechanical analysis as a linear thermal expansion and glass transition was performed to monitor the usefulness of the composites as radiation shields.

Radiation attenuation properties have been carried out using different thicknesses of the investigated composite samples vary from 3 to 18 cm and collimated radiation beams emitted from radioactive Pu-α- Be (5 Ci) neutron source. Fast neutron and gamma-ray spectra were measured by a neutron-gamma spectrometer with a stilbene organic scintillator based on the zero crossover method of the Pulse Shape Discrimination (PSD) technique. This technique was used to

discriminate against undesired pulses of recoil protons or electrons due to neutrons and gamma rays respectively.

The measured results of fast neutrons and total gamma rays are presented in the form of displayed spectra (energy distribution) for the different thicknesses of the investigated composites. These relations were used to derive the macroscopic effective removal cross-section Σ_R, total attenuation coefficient μ of fast neutrons, and gamma-rays respectively. Also, half-value layers (HVL) and relaxation lengths (λ) have been evaluated for the concerned composites.

MCNP5 code was used to calculate the macroscopic effective removal cross-section Σ_R of fast neutrons and attenuation coefficient μ of gamma-rays. Also, the WinXCom program was used to calculate the attenuation coefficient μ of gamma-rays. The obtained results showed that the AAc/B-Ilm composite gives the best results for all the investigated properties. Generally, considering the ilmenite's advantages is based principally on the attenuation of gamma-rays that have good value for a total attenuation (μ). Besides, the simulated results for gel-type composites at the selected energies were generally in good agreement with experimental results.

Keywords; Neutron source, Radiation shielding, Ilmenite, Hydrogel, Linear thermal expansion, Glass transition.

Contents

Page No

Acknowledgement i

Aim of work ii

Abstract iii

List of tables x

List of figures xiv

List of abbreviations xix

Chapter (1) Theoretical Aspects

1.1. Discovery of neutron…… 1

1.2. Gamma-rays sources …….……... 2

1.2.1. Reactor gamma-rays …….……..... 2

1.2.1.1. Prompt-fission gamma photons …….. 2

1.2.1.2. Fission-product gamma photons …… 3

1.2.1.3. Activation gamma photons ……. 3

1.2.2. Gamma-rays from other sources ……..……. 4

1.2.2.1. Radiative capture gamma photons ……. 4

1.2.2.2. Inelastic scattering gamma-rays ……. 5

1.2.2.3. Bremsstrahlung ……..... 5

1.3. Neutron sources …… 6

1.3.1. Neutrons produced from cosmic-ray particles ….. 6

1.3.2. Spontaneous-fission neutron sources……. 6

1.3.3. Neutrons from uranium fission ……. 7