Stopping Power of Electrons and Protons inPolyethylene TerephthalateC10H8O4, and PolyurethaneC17H16N2O4

Noor Hilal Hadi[a],Rashid Owaid Kadhim[b]
[a,b]Department of physics, College of Education for Girls, University of Kufa, Najaf, Iraq.

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Abstract: .In this work ,the entireprotons stopping power has been calculated by using Ziegler formula. The protons'energy range were (10-2 keV to 103 keV). The entireelectrons stopping power with using Bethe-Blochformula was designed, the verve range of electrons as of 10 keV to 105 keV in PolyurethaneC17H16N2O4, and Polyethylene terephthalate C10H8O4which as a polymeric materials for manufacture the astronaut suit.The results in this research were compared with the values of the E-STAR program for light charged particles (electrons) and the values of the SRIM program for the heavy charged particles (protons), and they showed good compatibility and all the mentioned equations were programmed in MATLAB2013 language.

Keywords: Stopping power, Electrons and proton, Bethe-Bloch formula, Ziegler formula, MATLAB language, SRIM2013.

1. Introduction

The cessation of energetic ions in the matter has been a topic for several years. It is of great importance to theoretical and experimental physicists. [1- 3], Bethe [4] and Bloch [5 ,6] were the leading hypotheticaldetectives. The charged units are stopping in the matter. Bohr, in his first articles [1- 3] ,it is proposed a methodintended to stopcontroldepending on the evidence that target atoms are traditional oscillators advanced[4], Bethe performed steadyimportantmechanics analysis and animportant eq. to define the discontinuing of fast charged particles which move in a quantified way. "Bloch"builtconnecting methodin the middle of the two. Traditional"Bohr"effect factormethod and quantum methodology. Herealized an updated "Bethe"formulation called "Bethe-Bloch equation" [5, 6]. This calculationdecreases the "Bohr"formulationinsmall velocity and the" Bethe"formulation, at great speed. In addition, the Bethe's strengthened Moller[7] and Bethe[8].

Discontinuingmodel by incorporating relativistic alterations. But, the ideas of "Bohr, and Bethe" can just be true for fast elements. Either way,these two theoriesare utilized now days with the fast speeds. from another hand, for slow elements, the principle of stopping power reducedissue was further established by "Fermi and Teller"[9]. Theypreservedboardaverageby way of anallowed electron gas andelectricdiscontinuing power plan that has arelation withspeed of the shell[10].

A medium's discontinuing power may be clear as the normal energy loss partknowledgeable by the elements of charge each unit pathwaydistance in the middle inrespect[11, 12]. Two basics consist of stopping power: impacts and energy. The main is the most significant result of the communicationamong the eventunits and the nuclear electrons formimpactpreventing power is commonly utilized for decreasing the averagemass dependency (ρ)[12]. Absolute discontinuing power might be derived from (SRIM-2003)[13], which uses the quantum mechanical treatment of ionatom collision to measure stopping power and ion spectrum (10eV– 2GeV/amu) in matter (the SRIM manual denotes to the atom movement as a 'ion' and all objective atoms as a 'atom')Ziegler and Biersack [11] offered a complete summary of the measurement.

A medium's stopping power may be definiteby means of the typical energy loss unit experienced by the particles of charge in unit pathway length in the intermediateunder deliberation. [12, 14] Many physicists have unrushed the energy loss in matter, but the elementary, standard derivation was credited to "Bloch", the one whoenhanced Bethe 's estimate, thus the "Bethe-Bloch"method.The energy loss ratecan be written by(– dE/dx); dE/dx actuality a loss of vigor, is a adverseworth[15].

2. Theory

Bethe-BlochFormula

Bethe[4] has derived an alternative stopping power formula. In contrast to Bohr, from the point of view of quantum mechanism, "Bethe"derivative a discontinuing powermethod insituation of a high-speedmissile. Classical countenancethe stopping plan for a gas target of the free electron could be as follow [16]:

$$S(Z,v)=\left(\frac{Ze\omega_p}{v}\right)^2 \ln\frac{2m_eM_pv^2}{(m_e+M_p)\omega_p\hbar} \quad (1)$$

Someplace v, Ze and M_p indicate the speed, charge, and mass of the projectile. $\omega_p$refersto the classical plasma frequency gained from the relationship $\omega_{p}=\sqrt{\frac{4\pi ne^2}{m_e}}$ as (n) is the density numberof electrons, m_e is themass ofelectron . Also, for heavyweightmissile Mp >> me the stopping power in Eq.(1) decreases to :

$$S(Z,v) = \left(\frac{Ze\omega_p}{v}\right)^2 \ln\frac{2m_e v^2}{\omega_p \hbar} \quad (2)$$

Two suppositions have been used in this derivation: the stopping caused from excitation and ionization of targ et electrons from Coulom. Moreover, Interface is known as part of the first Born approximation. The stopping nu mber L_{Bethe} reads,

$$L_{Bethe} = \sum_j f_j \; ln\left(\frac{2m_e v^2}{\hbar\omega_j}\right) \quad (3)$$

Where $\hbar\omega_j$ is the energy that corresponds to the j^{th} excitation of electrons in the target atoms andf_j is the generalized force of the oscillator (GOS). In reality, it is very difficult to measure the j^{th} electronic excitement, instead of that, measuring the average energy of the excitement is possible to do and the excitation energy defines itself :

$$Ln\, I = \sum_j f_j \ln(\hbar\omega_j) \quad (4)$$

It can be come close to spending widely use scrambling relationship[6]

$$I \approx 10Z_2\, eV \quad (5)$$

So as to justice the consistency the two both theories and the theory of Bethe to predicte electronics opping power, the effects of electronic stopping power have been presnted. Stopping power of the proton going over the Si target [17].

Ziegler Formula

To close the difference between the high- and low energy theories, interpolation formulas of various degrees of sophistication were suggested by Varelas and Biersa [18].

$$(S)^{-1} = (S_{LOW})^{-1} + (S_{HIGH})^{-1} \quad (6)$$

or

$$(S)^{-1} = S_{LOW}S_{HIGH}/(S_{LOW} + S_{HIGH}) \quad (7)$$

Where S_{LOW} (low stopping power), with$S_{LOW} = A_1E^{1/2}$And S_{HIGH} (high stopping power), with

$$S_{HIGH} = \frac{A_2}{E}\ln\left(1 + \frac{A_3}{E} + EA_4\right) \quad (8)$$

Here A_1,A_2 ,A_3 and A_4 are fitting constants.

At high energy, the fitting formula eq.(3) asymptotically agrees with eq(1).

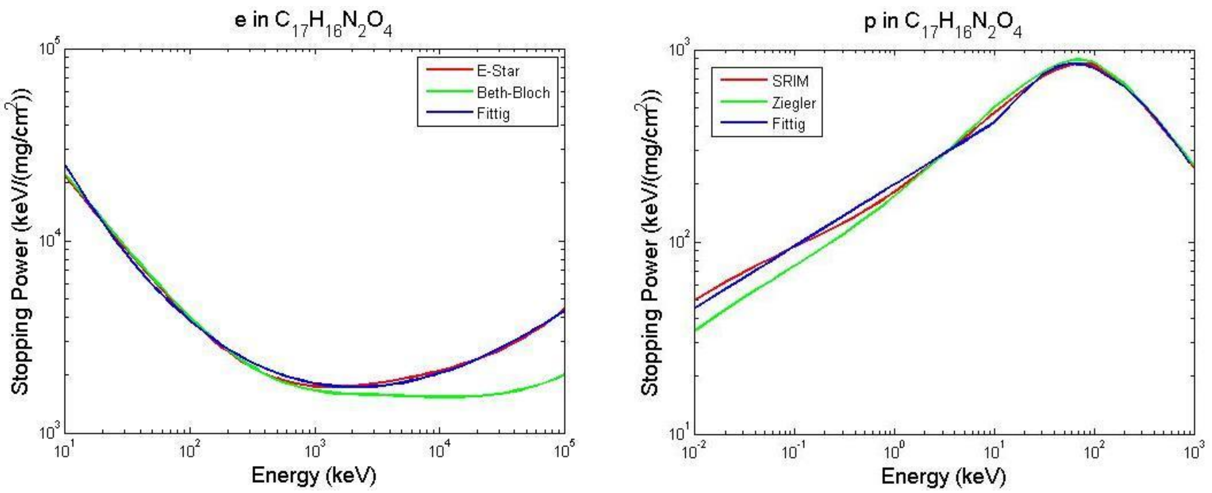
In addition, as the Varelas_Biersack formula is even simpler and has the correct asymptotic action at both high and low energy levels, Eq.

In general, (3) is used for fitting approximation curves[18].

3. Results And Discussion

Stopping power was calculated by Ziegler and Bethe formula for the first time the stopping power wascalculated on two different types Polyurethane $C_{17}H_{16}N_2O_4$, and Polyethylene terephthalate $C_{10}H_8O_4$ which as a polymeric materials for manufacture the astronaut suit, and with a proton energy range of(10^{-2} keV to 10^3 keV), the electrons'energy range(10 keV to 10^5 keV).The program has been implemented in a language MATLAB 2013.

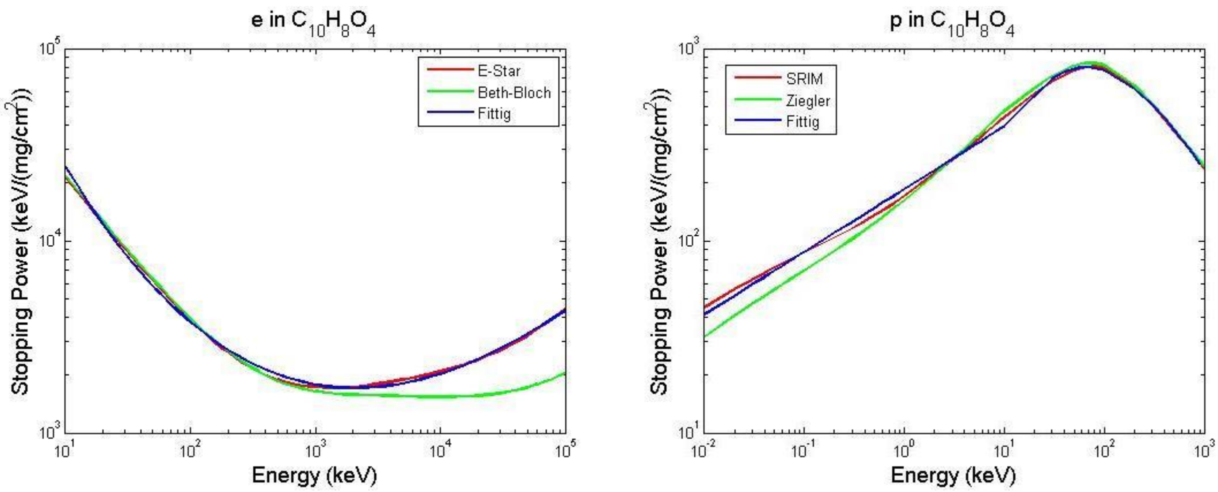
Polyurethane



(a) (b)

FIGURE 1. Total stopping power (a) forelectrons(b) forprotons in Polyurethane$C_{17}H_{16}N_2O_4$.

Polyethylene Terephthalate



(a) (b)

FIGURE 2. Total stopping power (a)forelectrons(b) forprotons inPolyethylene terephthalate$C_{10}H_8O_4$.

TABLE 1. Total stopping power for electron and proton in $C_{10}H_8O_4$ and $C_{17}H_{16}N_2O_4$.

E (keV)	**Total Stopping Power for electron keV/(mg/cm^2)**		**E (keV)**	**Total stopping power for proton keV/(mg/cm^2)**	
	$C_{10}H_8O_4$	**$C_{17}H_{16}N_2O_4$**		**$C_{10}H_8O_4$**	**$C_{17}H_{16}N_2O_4$**
10	21664.05	22054.08	0.01	31.45008	34.35136
100	3922.686	3982.651	0.1	69.83289	74.98105

1000	1642.979	1660.817	1	162.3784	172.8889
10000	1538.956	1538.807	10	470.1188	500.9041
20000	1560.986	1553.955	100	816.4049	856.6864
30000	1606.453	1593.999	200	640.4915	664.3721
40000	1662.16	1644.708	300	514.5034	531.0735
50000	1723.245	1700.957	400	434.381	447.2909
60000	1787.368	1760.353	500	379.335	390.0251
70000	1853.319	1821.663	600	338.7669	347.9368
80000	1920.411	1884.182	800	282.0056	289.1895
90000	1988.221	1947.476	900	261.0979	267.5906
100000	2056.477	2011.265	1000	243.4613	249.3883

TABLE 2. Rates of elements in $C_{10}H_8O_4$ and $C_{17}H_{16}N_2O_4$.

Polymer	**C**	**H**	**N**	**O**
$C_{10}H_8O_4$	0.6250	0.0420	0.0000	0.3330
$C_{17}H_{16}N_2O_4$	0.6538	0.0516	0.0897	0.2049

TABLE 3. The coefficient of correlation of $C_{10}H_8O_4$ and $C_{17}H_{16}N_2O_4$.

Polymer	**For electron**	**For proton**
$C_{10}H_8O_4$	0.9892	0.9996
$C_{17}H_{16}N_2O_4$	0.9895	0.9997

4. Conclusions

We conclude that the Bethe formula is suitable for thecontrol of the electronstopping power in the studied polymers.

We conclude that the Ziegler formula is suitable for the calculation of the proton stopping power in the studied polymers.

From Figures 1 and 2 banal (a), Calculations indicate that S_{tot} decreases with increasing energy of the incident electrons at the energies (10 - 10^3) keV because of the impactdiscontinuing power is the effect, then the total discontinuing power increases by increasing the energy of in incident electrons at the energies (10^3 - 10^5) keV because the radiative stopping power is effective, and this energy depends on the speed of the electrons that limit the type of interactions with the target and depends on the speed of the electrons that determine the type of interactions with the target.

From Figures 1 and 2 banal (b), we note that the total discontinuing power is increases with increasing energy of the incident protons at the energies (10^{-2} - 50) keV due to the occurrence of ionization and irritation of the atoms of the medium, which prevail in energy loss. In the range of energy (10^2– 10^3) keV,we note that the total discontinuing power is decreases with increasing energy of the incident protons because the electronic shutdown is prevalent.

The results ofcorrelation coefficient (r) is very good at0.9892, 0.9996, 0.9895, and0.9997.

By calculating the Bethe-Blochformula and Ziegler formulato calculate the total stopping power in the studies polymer, it was found that results of the curve match are close to the E-star and SRIM results, respectively

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