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Edge Version of Multiplicative Connectivity Indices of $TUC_4C_8(R)$ Nanotube

P. Gayathri, Assistant Professor, Department of Mathematics, A.V.C.College (Autonomous), Mannampandal, Mayiladuthurai, Tamil Nadu, India.

S. Sunantha, Assistant Professor, Department of Mathematics, Vivekananda College of Arts and Science of Women, Thenpathi, Sirkali, Tamil Nadu, India. sgsunantha@gmail.com

Abstract **Mathematical chemistry deals with the applications of mathematics to chemistry. In mathematical chemistry, chemical graph theory is one of the branches, which concern the graph of molecular structure. Here, a molecular graph or chemical graph is a graphic representation of the chemical compound. In this paper, we calculate the degree based topological indices like multiplicative first and second Zagreb indices, multiplicative first and second hyper-Zagreb indices, general first and second multiplicative Zagreb indices, multiplicative sum connectivity, multiplicative product connectivity, multiplicative atom bond connectivity, multiplicative geometric-arithmetic index and general multiplicative geometric-arithmetic indices of $TUC_4C_8(R)$ nanotube.**

***Keywords* —Chemical graph theory, degree based topological indices, multiplicative indices, $TUC_4C_8(R)$ nanotube.**

I. Introduction

A simple graph is a graph without having self-loops and multiple edges. In this paper, let H is a simple molecular graph. Here the atoms are the nodes $V(H)$ and the bonds are the edges $E(H)$ of the graph. The degree $d_H(v)$ is the total number of adjacent vertices to v. Topological indices are numerical quantity of a graph, which specifies its topology. There are many topological indices, which are used in Quantitative Structure Property Relationship (QSPR) and qualitative Structure Activity Relationship (QSAR) studies.

$TUC_4C_8(R)$ Squares and octagons in Figure 1. Construct nanotube, an alternative sequence of squares C_4 and octagons C_8. It is a trivalent C_4C_8 decoration. In recent days, most researchers interested to study on topological indices of Nanotubes and nanotori [1-3]. The line graph $L(H)$ obtained by its vertex set corresponds to the edges of H; also, if the edges are adjacent then its two vertices are also adjacent [4-5].

The First and Second Multiplicative Zagreb indices [6]

$$II_1(K) = \prod_{u\in E(K)} d_K(u)^2$$

$$II_2(K) = \prod_{uv\in E(K)} d_K(u)d_K(v)$$

The New multiplicative version of first multiplicative Zagreb index [7]

$$II_1^*(K) = \prod_{uv\in E(K)} [d_K(u)+d_K(v)]$$

The First and second multiplicative Hyper-Zagreb indices [8]

$$HII_1(K) = \prod_{uv\in E(K)} [d_K(u)+d_K(v)]^2$$

$$HII_2(K) = \prod_{uv\in E(K)} [d_K(u)d_K(v)]^2$$

The General first and second multiplicative Zagreb indices [9].

$$MZ_1^a(K) = \prod_{uv\in E(K)} [d_K(u)+d_K(v)]^a$$

$$MZ_2^a(K) = \prod_{uv\in E(K)} [d_K(u)d_K(v)]^a$$

The Product connectivity index or Randic index [10].

$$\chi(K) = \sum_{uv\in E(K)} \frac{1}{\sqrt{d_K(u)d_K(v)}}$$

The multiplicative sum connectivity index [10].

$$XII(K) = \prod_{uv\in E(K)} \frac{1}{\sqrt{d_K(u)+d_K(v)}}$$

The multiplicative product connectivity index [10]

$$\chi II(K) = \prod_{uv\in E(K)} \frac{1}{\sqrt{d_K(u)d_K(v)}}$$

The multiplicative atom bond connectivity index [10]

$$ABCII(K) = \prod_{uv\in E(K)} \sqrt{\frac{d_K(u)+d_K(v)-2}{d_K(u)d_K(v)}}$$

The multiplicative geometric-arithmetic index [10]

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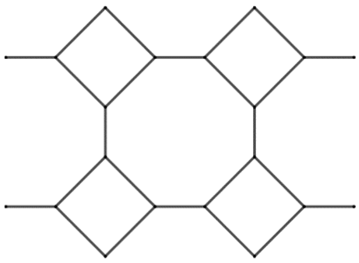
$$GAII(K) = \prod_{uv\in E(K)} \frac{2\sqrt{d_K(u)d_K(v)}}{d_K(u)+d_K(v)}$$

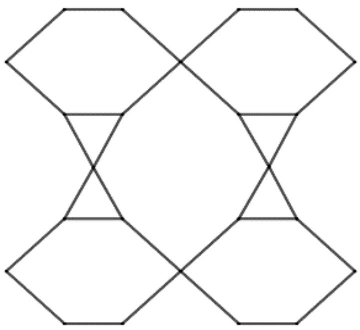
The general multiplicative geometric-arithmetic index [10]

$$GA^aII(K) = \prod_{uv\in E(G)} \left(\frac{2\sqrt{d_K(u)d_K(v)}}{d_K(u)+d_K(v)} \right)^a$$

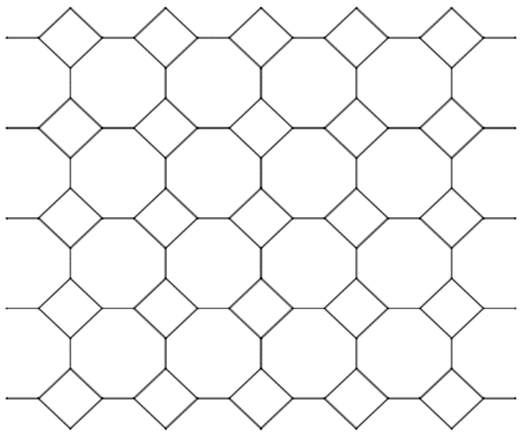
II. MAIN RESULTS



(a)



(b)



(c)

Figure 1:

Here, the Figure 1(a) represents the 2D lattice of $TUC_4C_8R[1,1]$ nanotube; Figure 1(b) represents the line graph of $TUC_4C_8R[1,1]$. In addition, the Figure 1(c) is the graph of $TUC_4C_8R[4,5]$.

Edge Partition of $L(H)$**:** We take $L(H)=K$ is the two dimensional lattice of $TUC_4C_8R[p,q]$ nanotube, where p denotes the number of rows and q denotes the number of columns. In line graph K, we obtain four types of edges such as (2, 2), (3, 3), (2, 4) and (3, 4). It depends on the degrees of the vertices. Here $E[L(H)]$ denotes the edge set.

Lemma 2.1. *For $L(H)=K$, where K two-dimensional lattice of $TUC_4C_8R[p,q]$ nanotube. It holds that*

$d_K(u), d_K(v) \setminus uv \in E[K]$	Number of edges
E	$6p+10q+10pq+6$
V	$6pq+5p+7q+6$
e_1	$2(p+1)$
e_2	$4(p+1)$
e_3	$2q(p+1)$
e_4	$8q(p+1)$

Where,
E *– Total number of edges*
V *– Total number of Vertices*
e_1 *– Total number of edges having (2, 2) degree*
e_2 *– Total number of edges having (2, 4) degree*
e_3 *– Total number of edges having (3, 3) degree*
e_4 *– Total number of edges having (3, 4) degree*

Proof. The following calculations obtained from the line graph shown in Figure 1 (b).

p	q	e_1	e_2	e_3	e_4	E	V
1	1	4	8	4	12	32	24
1	2	4	8	8	32	52	37
1	3	4	8	12	48	72	50
2	2	6	12	12	48	78	54
2	1	6	12	6	24	48	35
2	3	6	12	18	72	108	73
3	3	8	16	24	96	144	96

By using an algebraic method, we get $e_1=2(p+1)$, $e_2=4(p+1)$, $e_3=2q(p+1)$, $e_4=8q(p+1)$, $E=6p+10q+10pq+6$, and $V=5p+7q+6pq+6$.

Theorem 2.2. *Let K be 2-dimensional lattice of $TUC_4C_8(R)$ Nanotube. Then,*

(1). $II_1^*(K) = 2^{2q(p+1)+8p+8} \times 3^{2q(p+1)+4p+4} \times 7^{8q(p+1)}$

(2). $II_2(K) = 2^{16q(p+1)+16p+16} \times 3^{12q(p+1)}$

(3). $HII_1(K) = 2^{4q(p+1)+16p+16} \times 3^{4q(p+1)+8p+8} \times 7^{16q(p+1)}$

(4). $HII_2(K) = 2^{32q(p+1)+32p+32} \times 3^{24q(p+1)}$

(5). $XII(K) = 2^{-(p+1)(q+4)} \times 3^{-(p+1)(q+2)} \times 7^{-4q(p+1)}$

(6). $\chi II(K) = 2^{-8(p+1)(q+1)} \times 3^{-6q(p+1)}$

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(7). $MZ_1^a(K) = 2^{2a(p+1)(q+4)} \times 3^{2a(p+1)(q+2)} \times 7^{8aq(p+1)}$

(8). $MZ_2^a(K) = 2^{16aq(p+1)+16a(p+1)} \times 3^{4a(p+1)q+8aq(p+1)}$

(9). $ABCII(K) = 2^{-3(p+1)(2q+1)} \times 3^{-6q(p+1)} \times 5^{4q(p+1)}$

(10). $GAII(K) = 2^{16q(p+1)+6p+6} \times 3^{4q(p+1)-4p-4} \times 7^{-8q(p+1)}$

(11). $GA^a II(K) = 2^{16aq(p+1)+6a(p+1)} \times 3^{4aq(p+1)-4a(p+1)} \times 7^{-8aq(p+1)}$

Proof. By using the definitions of multiplicative indices and using the proposed Lemma 2.1, we get the following results.

(1). $$II_1^*(K) = \prod_{uv\in E(K)} [d_K(u)+d_K(v)]$$
$$= \prod_{uv\in e_1} 4 \times \prod_{uv\in e_2} 6 \times \prod_{uv\in e_3} 6 \times \prod_{uv\in e_4} 7$$
$$= 4^{2(p+1)} \times 6^{4(p+1)} \times 6^{2q(p+1)} \times 7^{8q(p+1)}$$
$$= 2^{2q(p+1)+8p+8} \times 3^{2q(p+1)+4p+4} \times 7^{8q(p+1)}$$

(2). $$II_2(K) = \prod_{uv\in E(K)} [d_K(u)d_K(v)]$$
$$= \prod_{uv\in e_1} 4 \times \prod_{uv\in e_2} 8 \times \prod_{uv\in e_3} 9 \times \prod_{uv\in e_4} 12$$
$$= 4^{2(p+1)} \times 8^{4(p+1)} \times 9^{2q(p+1)} \times 12^{8q(p+1)}$$
$$= 2^{16q(p+1)+16p+16} \times 3^{12q(p+1)}$$

(3). $$HII_1(K) = \prod_{uv\in E(K)} [d_K(u)+d_K(v)]^2$$
$$= \prod_{uv\in e_1} 4^2 \times \prod_{uv\in e_2} 6^2 \times \prod_{uv\in e_3} 6^2 \times \prod_{uv\in e_4} 7^2$$
$$= 4^{4(p+1)} \times 6^{8(p+1)} \times 6^{4q(p+1)} \times 7^{16q(p+1)}$$
$$= 2^{4q(p+1)+16p+16} \times 3^{4q(p+1)+8p+8} \times 7^{16q(p+1)}$$

(4). $$HII_2(K) = \prod_{uv\in E(K)} [d_K(u)d_K(v)]^2$$
$$= \prod_{uv\in e_1} 4^2 \times \prod_{uv\in e_2} 8^2 \times \prod_{uv\in e_3} 9^2 \times \prod_{uv\in e_4} 12^2$$
$$= 4^{4(p+1)} \times 8^{48p+1)} \times 9^{4q(p+1)} \times 12^{16q(p+1)}$$
$$= 2^{32q(p+1)+32p+32} \times 3^{24q(p+1)}$$

(5). $$XII(K) = \prod_{uv\in E(K)} \frac{1}{\sqrt{d_K(u)+d_K(v)}}$$
$$= \prod_{uv\in e_1} \frac{1}{\sqrt{4}} \times \prod_{uv\in e_2} \frac{1}{\sqrt{6}} \times \prod_{uv\in e_3} \frac{1}{\sqrt{6}} \times \prod_{uv\in e_4} \frac{1}{\sqrt{7}}$$
$$= \left(\frac{1}{\sqrt{4}}\right)^{2(p+1)} \times \left(\frac{1}{\sqrt{6}}\right)^{4(p+1)} \times \left(\frac{1}{\sqrt{6}}\right)^{2q(p+1)} \times \left(\frac{1}{\sqrt{7}}\right)^{8q(p+1)}$$
$$= 2^{-(p+1)(q+4)} \times 3^{-(p+1)(q+2)} \times 7^{-4q(p+1)}$$

(6). $$\chi II(K) = \prod_{uv\in E(K)} \frac{1}{\sqrt{d_K(u)d_K(v)}}$$
$$= \prod_{uv\in e_1} \frac{1}{\sqrt{4}} \times \prod_{uv\in e_2} \frac{1}{\sqrt{8}} \times \prod_{uv\in e_3} \frac{1}{\sqrt{9}} \times \prod_{uv\in e_4} \frac{1}{\sqrt{12}}$$
$$= \left(\frac{1}{\sqrt{4}}\right)^{2(p+1)} \times \left(\frac{1}{\sqrt{8}}\right)^{4(p+1)} \times \left(\frac{1}{\sqrt{9}}\right)^{2q(p+1)} \times \left(\frac{1}{\sqrt{12}}\right)^{8q(p+1)}$$
$$= 2^{-8(p+1)(q+1)} \times 3^{-6q(p+1)}$$

(7). $$MZ_1^a(K) = \prod_{uv\in E(K)} [d_K(u)+d_K(v)]^a$$
$$= \prod_{uv\in e_1} 4^a \times \prod_{uv\in e_2} 6^a \times \prod_{uv\in e_3} 6^a \times \prod_{uv\in e_4} 7^a$$
$$= 4^{2a(p+1)} \times 6^{4a(p+1)} \times 6^{2aq(p+1)} \times 7^{8aq(p+1)}$$
$$= 2^{2a(p+1)(q+4)} \times 3^{2a(p+1)(q+2)} \times 7^{8aq(p+1)}$$

(8). $$MZ_2^a(K) = \prod_{uv\in E(K)} [d_K(u)d_K(v)]^a$$
$$= \prod_{uv\in e_1} 4^a \times \prod_{uv\in e_2} 8^a \times \prod_{uv\in e_3} 9^a \times \prod_{uv\in e_4} 12^a$$
$$= 4^{2a(p+1)} \times 8^{4a(p+1)} \times 9^{2aq(p+1)} \times 12^{8aq(p+1)}$$
$$= 2^{16aq(p+1)+16a(p+1)} \times 3^{4a(p+1)q+8aq(p+1)}$$

(9). $$ABCII(K) = \prod_{uv\in E(K)} \sqrt{\frac{d_K(u)+d_K(v)-2}{d_K(u)d_K(v)}}$$
$$= \prod_{uv\in e_1} \sqrt{\frac{2+2-2}{2\times 2}} \times \prod_{uv\in e_2} \sqrt{\frac{2+4-2}{2\times 4}} \times \prod_{uv\in e_3} \sqrt{\frac{3+3-2}{3\times 3}} \times \prod_{uv\in e_4} \sqrt{\frac{3+4-2}{3\times 4}}$$
$$= \left(\frac{1}{\sqrt{2}}\right)^{2(p+1)} \times \left(\frac{1}{\sqrt{2}}\right)^{4(p+1)} \times \left(\frac{2}{3}\right)^{2q(p+1)} \times \left(\sqrt{\left(\frac{5}{12}\right)}\right)^{8q(p+1)}$$
$$= 2^{-3(p+1)(2q+1)} \times 3^{-6q(p+1)} \times 5^{4q(p+1)}$$

(10). $$GAII(K) = \prod_{uv\in E(K)} \frac{2\sqrt{d_K(u)d_K(v)}}{d_K(u)+d_K(v)}$$
$$= \prod_{uv\in e_1} \frac{2\sqrt{2\times 2}}{2+2} \times \prod_{uv\in e_2} \frac{2\sqrt{2\times 4}}{2+4} \times \prod_{uv\in e_3} \frac{2\sqrt{3\times 3}}{3+3} \times \prod_{uv\in e_4} \frac{2\sqrt{3\times 4}}{3+4}$$
$$= \left(\frac{2\sqrt{2}}{3}\right)^{4(p+1)} \times \left(\frac{4\sqrt{3}}{7}\right)^{8q(p+1)}$$
$$= 2^{16q(p+1)+6p+6} \times 3^{4q(p+1)-4p-4} \times 7^{-8q(p+1)}$$

(11). $$GA^a II(G) = \prod_{uv\in E(G)} \left(\frac{2\sqrt{d_G(u)d_G(v)}}{d_G(u)+d_G(v)}\right)^a$$
$$= \prod_{uv\in e_1} \left(\frac{2\sqrt{2\times 2}}{2+2}\right)^a \times \prod_{uv\in e_2} \left(\frac{2\sqrt{2\times 4}}{2+4}\right)^a \times \prod_{uv\in e_3} \left(\frac{2\sqrt{3\times 3}}{3+3}\right)^a \times \prod_{uv\in e_4} \left(\frac{2\sqrt{3\times 4}}{3+4}\right)^a$$
$$= \left(\frac{2\sqrt{2}}{3}\right)^{4a(p+1)} \times \left(\frac{4\sqrt{3}}{7}\right)^{8aq(p+1)}$$
$$= 2^{16aq(p+1)+6a(p+1)} \times 3^{4aq(p+1)-4a(p+1)} \times 7^{-8aq(p+1)}$$

III. CONCLUSION

We have presented here multiplicative indices of line graph of $TUC_4C_8(R)$ nanotube. The topological indices of molecular graph can be used to analyze the characteristics of Nano materials. In addition, it will help to understand the Physical features, Chemical reactivity and Biological activities of Nano tubes. In pharmaceutical industry, these results can provide a significant determination.

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