

بررسی روشهای تولید نانو تیوب های کربنی و انتخاب بهترین روش ساخت مناسب با استفاده از روش تصمیم گیری چند معیاره

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چکیده

(Carbon Nanotubes, CNT) ()

CNT

CNT

CNT

- CVD - CVD - - - - - :
AHP -

[]

CNT

CNT

()

(MWNT)

(SWNT)

CNT

(h-MWNT)

(c-MWNT)

CNT

[]

[] c-MWNT h-MWNT

SWNT

SWNT

[] ()

[]

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[]

()

SWNT

SWNT

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()

(1000k<t<6000k)

()

C₆₀

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به عنوان مثال بسته به مقدار انرژی مورد استفاده،
قطعه هدف که به صورت جامد است، گرم و یا ذوب و یا
حتی تبخیر می‌شود. امروز دو نوع دستگاه لیزری برای
تولید نانو تیوبهای کربنی وجود دارد. در یکی، از اشعه لیزر
به صورت پالسی استفاده می‌شود و در دیگری به صورت
پیوسته، که در دومی تاثیر آن کمتر است [۶].

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SWNT	.						•
		2100k	1000k				•
				SWNT			
		SWNT	:				•
[]							•
			:				•
							•
							•
		SWNT	DWNT			300 nm	
SWNT		()		(Co ,Ni)	
SWNT		SWNT					
				[]			MWNT
		SWNT		SWNT			
SWNT	Ni-Y						
Rh-Pd		SWNT.					
			5-20 nm				10- 100
					1200°C		
							SWNT
				SWNT			
		SWNT		HiPCo™			CCVD
				SWNT			
				() 0/03 \$/g	

MWNT

20kg, 2003

SWNT

(SWNT) .

SWNT

- (/) -

(..)

SWNT

He

MWNT

CH₄

[] []

MWNT

)

(

MWNT

SWNT

500°C

(Ni, Co, Fe, Pt, Pd, etc)

Ni-Co

CNT

در روش قوس الکتریکی نانو تیوب‌های دو جداره^{۱۰} هم همانند SWNT های با قطر زیاد، تولید می‌شوند، حتی

C₆₀ :

می توان با استفاده از یک جریان DC، SWNT های بیشتری هم تولید کرد. در مجموع رشد دادن CNT های هم راستا (MWNTs, DWNTs, SWNTs) با روش قوس الکتریکی مشکل است، البته می توان هم راستائی های جزئی با روش های همرفت یا روش قوس الکتریکی مستقیم توسط پلاسما بوجود آورد. از طرفی درجه حرارت رشد در روش قوس الکتریکی بالاتر از دیگر روش های تولید CNT ها می باشد و در نتیجه محصولات بوجود آمده با این روش ساختار کاملی دارند، تنها عیبی که در ساختار آنها وجود دارد هم راستایی کم آنها می باشد.

CCVD

CCVD

SWNT

nm

MWNT

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-
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CCVD

CVD

)

CCVD

(

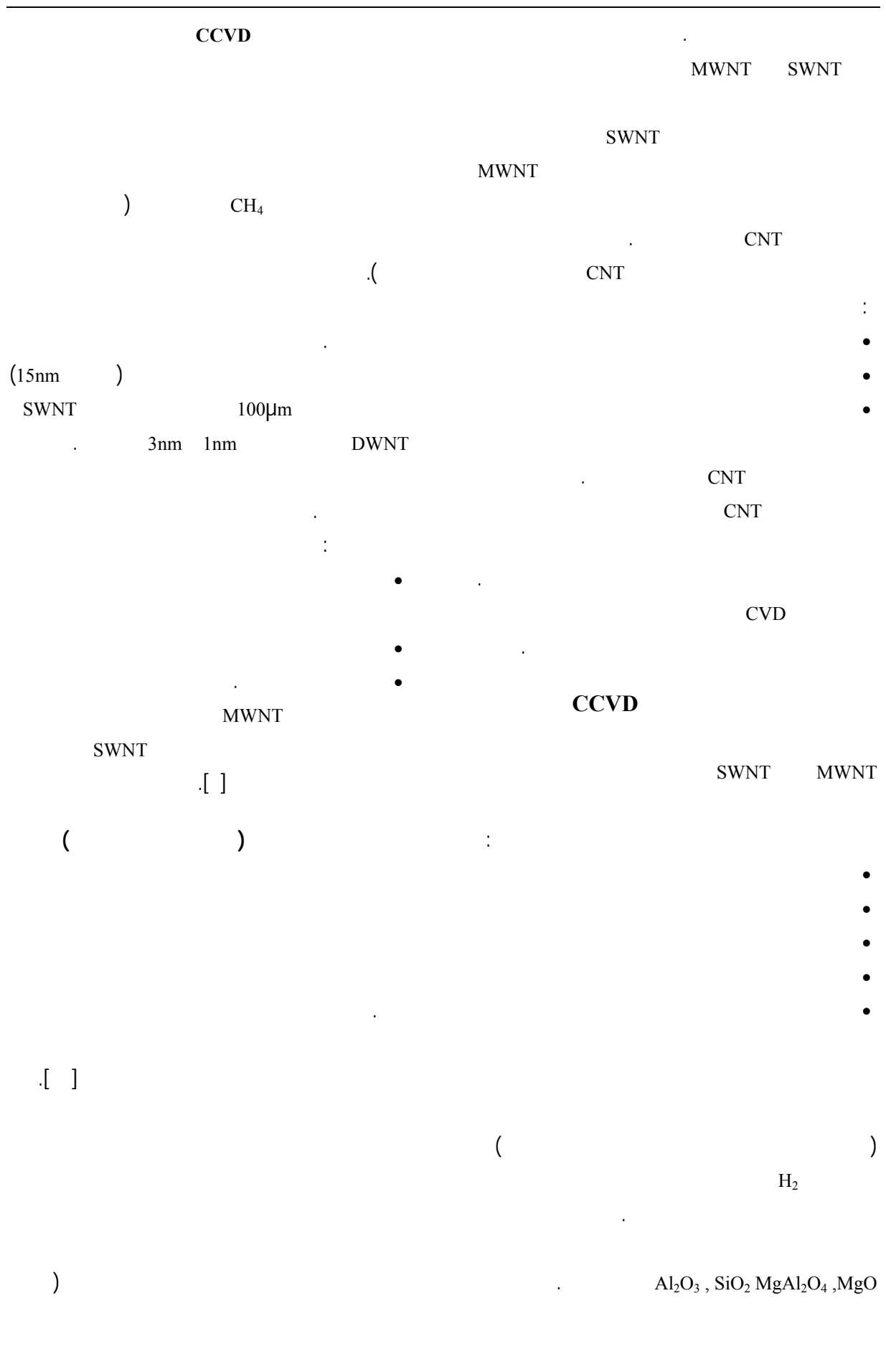
CVD

CNT

CNT

CNT

Ni, Co, Fe



•
•
) .

.(MWNT

(CCVD)

) MWNT

(4nm)

SWNT (

)
(SWNT

C-N

(AHP)

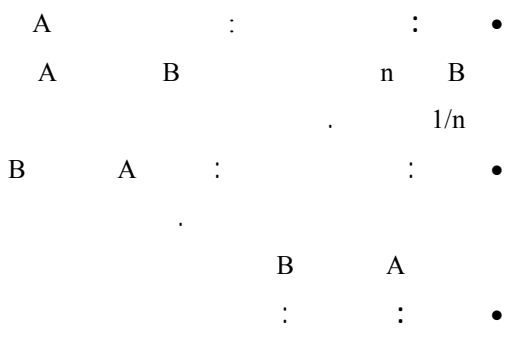
HiPCo™ SWNT

(Templating)

-
-
-

(AHP)

$$\begin{matrix}
 & j & i & a_{ij} \\
 W_i & & & a_{ij} \\
 & W_i & & \\
 & : & & \\
 a_{11}w_1 + a_{12}w_2 + \dots + a_{1n}w_n = \lambda \cdot w_1 & & & \\
 a_{21}w_1 + a_{22}w_2 + \dots + a_{2n}w_n = \lambda \cdot w_2 & & & \\
 \dots & & & \\
 \dots & & & \\
 a_{n1}w_1 + a_{n2}w_2 + \dots + a_{nn}w_n = \lambda \cdot w_n & & & \\
 & & & \lambda
 \end{matrix}
 \quad ()$$



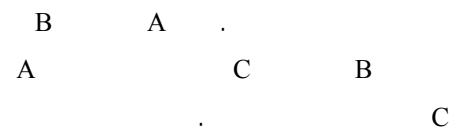
$$w_i = \frac{1}{\lambda} \sum_{j=1}^n a_{ij} w_j \quad i=1,2,\dots,n \quad ()$$

$$A \times W = \lambda \cdot W \quad ()$$

$$\begin{matrix}
 & & & w_i \\
 & & A & \\
 & & (A - \lambda I) & \\
 & & \lambda & \\
 & & (A - \lambda I) & \\
 \lambda_{\max} & \lambda & & \\
 (A - \lambda_{\max} I) \times W = 0 & & & \\
 W_i & (A - \lambda_{\max} I) \times W = 0 & &
 \end{matrix}$$

[]

$$\begin{matrix}
 P & & W \\
 & (P-1) & Z \\
 & (q > p) & q & (W) \\
 & & & \\
 & & & Z \\
 W = C_d \cdot C_{d-1} \dots C_3 \cdot W^2 \cdot 1 & & & () \\
 W = C_q \cdot C_{q-1} \dots C_{p+1} \cdot W & & & () \\
 & & & \\
 & & & \bullet
 \end{matrix}$$



HiPCo™ •

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CVD

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(Expert Choice) EC

CVD

CVD

PECVD

CVD

PECVD

CVD

CVD

CVD

CVD

CVD

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CVD

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CVD

(PECVD)

-CVD

:

■ The best method of Carbon Nano-tube synthesis for Iran

- Specifications of the CNTs (L: .148 G: .148)
 - Controlling the diameter of CNTs (L: .176 G: .026)
 - The length of CNTs (L: .178 G: .026)
 - Not having structural defects (L: .162 G: .024)
 - Having Small Diameter (L: .108 G: .016)
 - Having crystal structure (L: .101 G: .015)
 - Synthesising different shapes of CNTs (L: .137 G: .020)
 - Alignment (L: .139 G: .021)
- Purification processes (L: .086 G: .086)
 - Simple procedure (L: .545 G: .047)
 - One step procedure(Short procedure) (L: .455 G: .039)
- Temperature of Synthesis (L: .090 G: .090)
- Machineries (L: .110 G: .110)
 - Cost of buying machineries (L: .461 G: .051)
 - Having expert engineers (L: .318 G: .035)
 - Maintenance (L: .221 G: .024)
- Production Rate (L: .175 G: .175)
- Cost of CNTs Synthesis (L: .129 G: .129)
- Mass production (L: .112 G: .112)
- Having simple procedure (L: .045 G: .045)
- scale up (L: .105 G: .105)

CVD
 CVD - °C
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 CVD

CVD
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CVD
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CVD
 ()
 - :
)
) - (CNT
) -
 MWNT SWNT
 - (CNT -
 -
 (AHP) ()
) - :

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AHP

ie best method in Gaseous Carbon Source-Based Production Techniques

- Raw material (L: .086 G: .086)
- Raw material for Purification Process (L: .743 G: .064)
- Raw material for Carbon Nano-tube synthesis (L: .257 G: .022)
- Specification of CNTs (L: .115 G: .115)
- CNTs Purity (L: .545 G: .063)
- CNTs Alignment (L: .455 G: .052)
- CNTs purification process (L: .066 G: .066)
- Number of purification process needed (L: .667 G: .044)
- Need catalyst purification from CNT (L: .333 G: .022)
- Machineries (L: .148 G: .148)
- Number of machineries needed (L: .146 G: .022)
- Need cleaning the walls of reactor from sediment (L: .142 G: .021)
- Flexibility of process(Synthesis SWNT & MWNT with little changes in process) (L: .352 G: .052)
- Pressure and temperature of process (L: .222 G: .033)
- Less stages to produce CNTs (L: .138 G: .020)
- Residence time (L: .138 G: .138)
- Price of CNTs (L: .147 G: .147)
- Can be used in Industrial production (L: .160 G: .160)
- To be economic (L: .141 G: .141)

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EC

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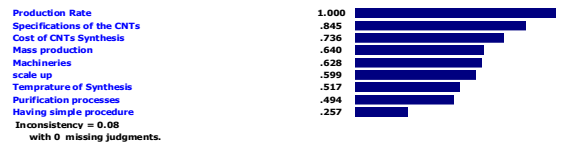
Synthesis with respect to:

The best method of Carbon Nano-tube synthesis for Iran
Overall Inconsistency = .08



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Priorities with respect to:
The best method of Carbon Nano-tubesynthesis for Iran



The best method of carbon Nanotubes synthesis for Iran

. AHP :

Circle one number per row below using the scale:
 1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Specifications of the	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Purification process
2	Specifications of the	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Temprature of Synt
3	Specifications of the	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Machineries
4	Specifications of the	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Production Rate
5	Specifications of the	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Cost of CNTs Synth
6	Specifications of the	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Mass production
7	Specifications of the	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Having simple proce
8	Specifications of the	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	scale up
9	Purification process	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Temprature of Synt
10	Purification process	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Machineries
11	Purification process	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Production Rate
12	Purification process	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Cost of CNTs Synth
13	Purification process	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Mass production
14	Purification process	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Having simple proce
15	Purification process	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	scale up
16	Temprature of Synt	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Machineries
17	Temprature of Synt	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Production Rate
18	Temprature of Synt	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Cost of CNTs Synth
19	Temprature of Synt	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Mass production
20	Temprature of Synt	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Having simple proce
21	Temprature of Synt	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	scale up
22	Machineries	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Production Rate
23	Machineries	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Cost of CNTs Synth
24	Machineries	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Mass production
25	Machineries	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Having simple proce
26	Machineries	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	scale up
27	Production Rate	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Cost of CNTs Synth
28	Production Rate	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Mass production
29	Production Rate	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Having simple proce
30	Production Rate	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	scale up
31	Cost of CNTs Synth	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Mass production
32	Cost of CNTs Synth	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Having simple proce
33	Cost of CNTs Synth	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	scale up
34	Mass production	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Having simple proce
35	Mass production	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	scale up
36	Having simple proce	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	scale up

AHP

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AHP

Expert

"Choice"

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"Expert Choice"

AHP

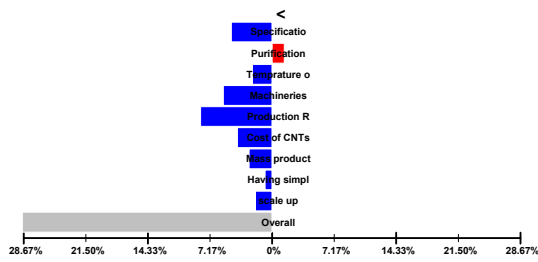
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Performance

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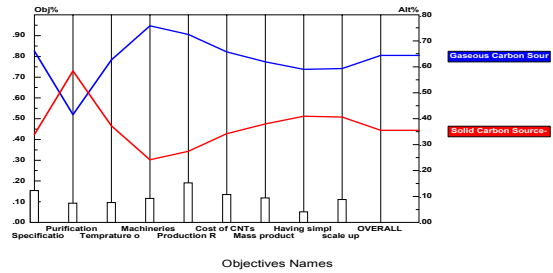
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Weighted head to head between Gaseous Carbon Source-Based Production Techniques for Carbon Nanotubes and Solid Carbon Source-Based Production Techniques for Carbon Nanotubes



. Dimensional :

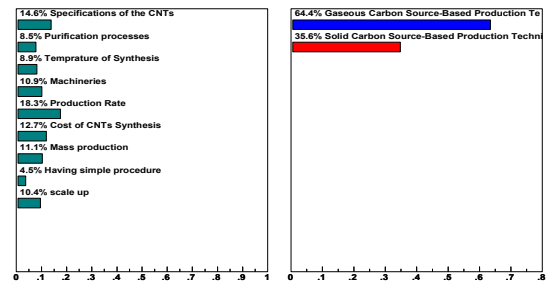
Performance Sensitivity for nodes below: The best method of Carbon Nano-tube synthesis for Iran



Objectives Names	
Specification	Specifications of the CNTs
Purification	Purification processes
Temperature o	Temperature of Synthesis
Machineries	Machineries
Production R	Production Rate
Cost of CNTs	Cost of CNTs Synthesis
Mass product	Mass production
Having simpl	Having simple procedure
scale up	scale up

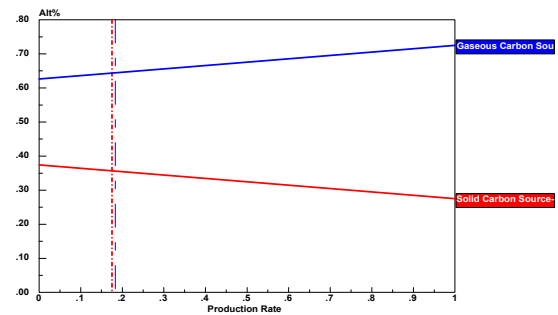
() Dynamic

Dynamic Sensitivity for nodes below: The best method of Carbon Nano-tube synthesis for Iran



. Dynamic :

Gradient Sensitivity for nodes below: The best method of Carbon Nano-tube synthesis for Iran



. Gradient :

() Gradient

() Dimensional

PECVD

- CVD •
- CVD •
- PECVD •

Synthesis: Summary

Synthesis with respect to:

The best method in Gaseous Carbon Source-Based Production Techniques

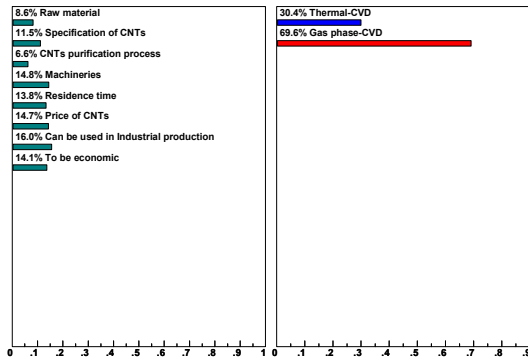
Overall Inconsistency = .10



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Dynamic Sensitivity for nodes below: The best method in Gaseous Carbon Source-Based Production Techniques



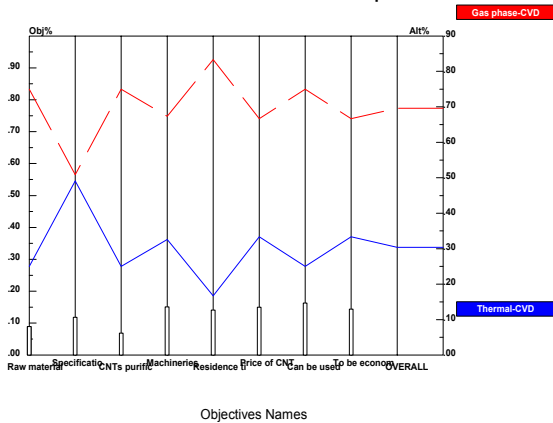
Dynamic :

()
-CVD

**Priorities with respect to:
The best method in Gaseous Carbon Source-Based Production Techniques**



Performance Sensitivity for nodes below: The best method in Gaseous Carbon Source-Based Production Techniques



Objectives Names

Raw material	Raw material
Specificatio	Specification of CNTs
CNTs purific	CNTs purification process
Machineries	Machineries
Residence ti	Residence time
Price of CNT	Price of CNTs
Can be used	Can be used in Industrial production
To be econom	To be economic

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|------------------------------------|---------------------------------------|
| 1 - Single wall Nanotubes | 2 -Multi wall Nanotube |
| 3 - Concentric Multi wall Nanotube | 4 -herringbone Multi wall Nanotube |
| 5 - Bamboo | 6 - Acolt S.A |
| 7 - Nanoledge S.A | 8 - Montpellier |
| 9 - Bucky | 10 - DWNT (Double Wall Nanotubes) |
| 11 - Rice | 12 - Analytical Hierarchy Process |
| 13 - Axioms | 14 - Tomas L. Saati |
| 15 - Reciprocal Condition | 16 - Homogeneity |
| 17 - Dependency | 18 - Expectations |
| 19 - Least Squares Method | 20 - Logarithmic Least Squares Method |
| 21 - Eigenvector Method | 22 - Approximation Methods |
| 23 - Harker | 24 - Thermal |
| 25 - Gas-Phase | 26 -Plasma |
| 27 - Unsupported-Catalyst | 28 - Floating Catalyst |
| 29 - Thermal-CVD | 30 -Gas phase-CVD |
| 31 - Inconel | 32 - Inconsistency Ratio |
-