ABSTRACT

SOLVENT-BASED METHODS FOR PRODUCTION OF GRAPHENE NANORIBBONS

The present invention provides methods of preparing functionalized graphene nanoribbons. Such methods include: (1) exposing a plurality of carbon nanotubes (CNTs) to an alkali metal source in the presence of an aprotic solvent to open them; and (2) exposing the opened CNTs to an electrophile to form functionalized graphene nanoribbons (GNRs). The methods may also include a step of exposing the opened CNTs to a protic solvent to quench any reactive species on them. Additional methods include preparing unfunctionalized GNRs by: (1) exposing a plurality of CNTs to an alkali metal source in the presence of an aprotic solvent to open them; and (2) exposing the opened CNTs to a protic solvent to form unfunctionalized GNRs.

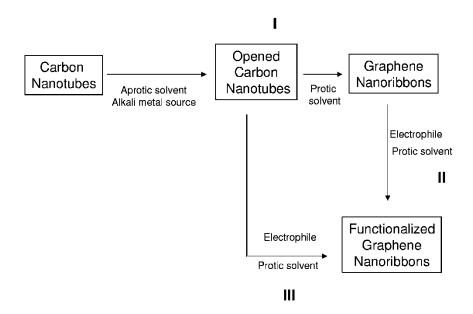


FIG. 1

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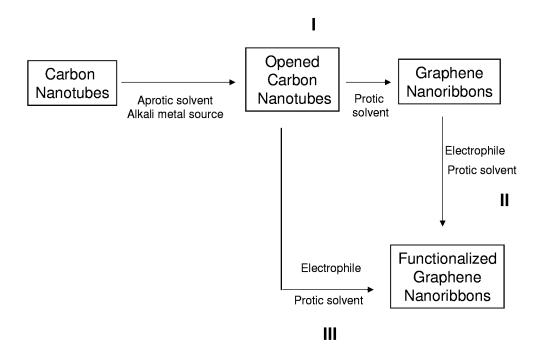


FIG. 1

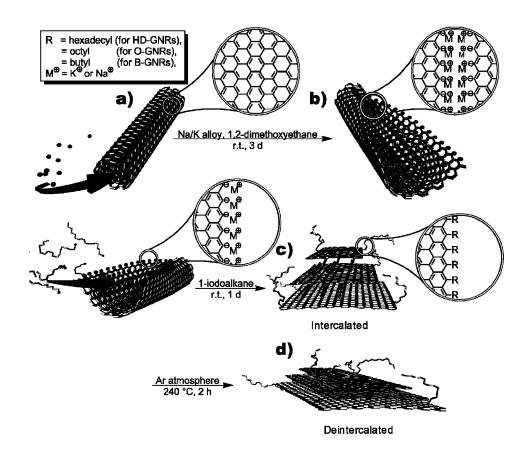


FIG. 2

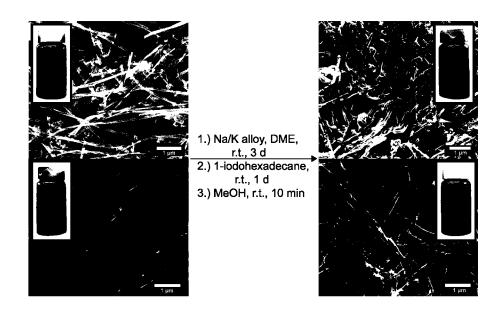


FIG. 3

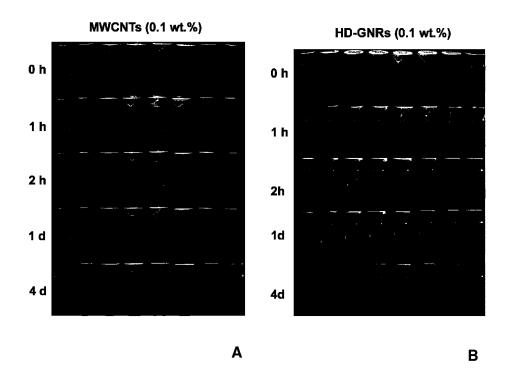


FIG. 4

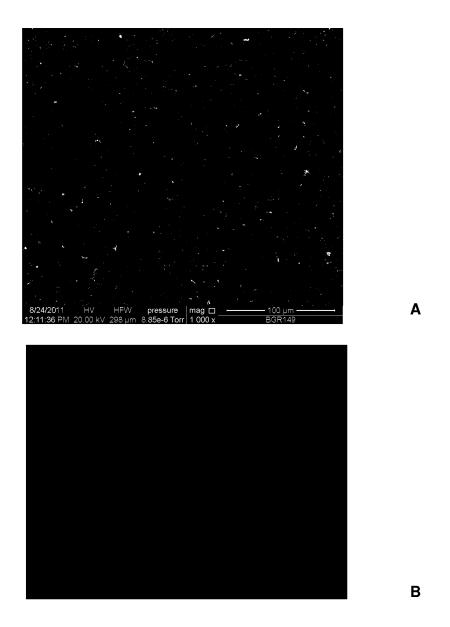


FIG. 5

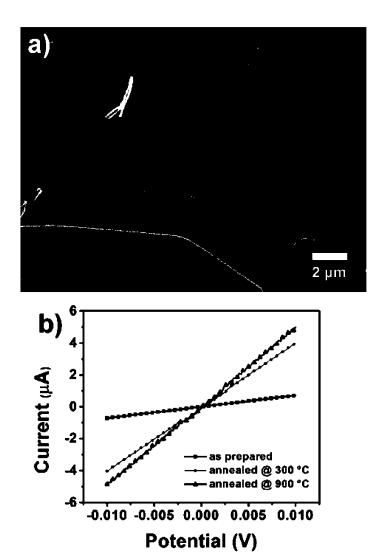


FIG. 6

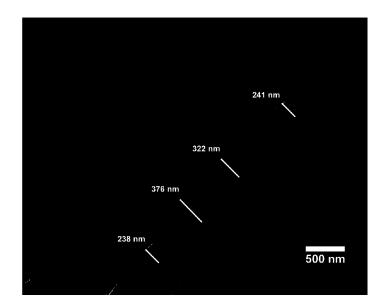
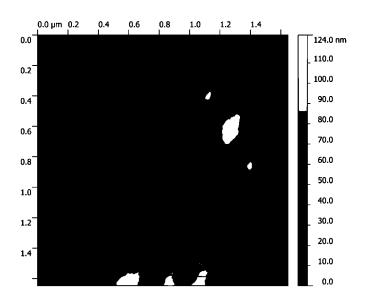
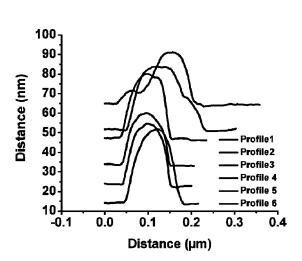
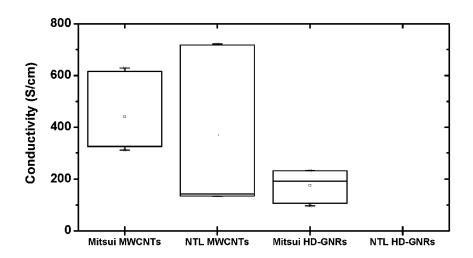


FIG. 7





Α



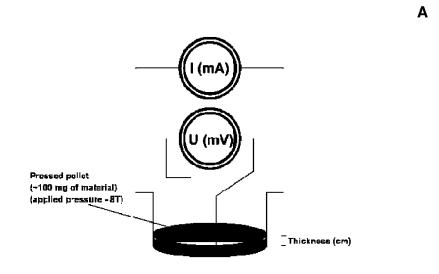


FIG. 9

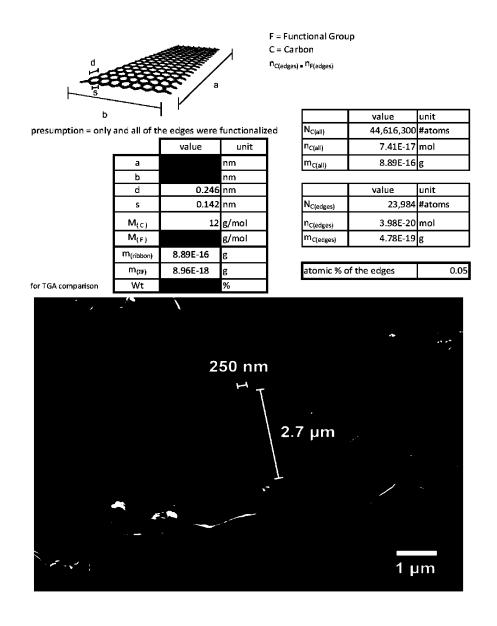
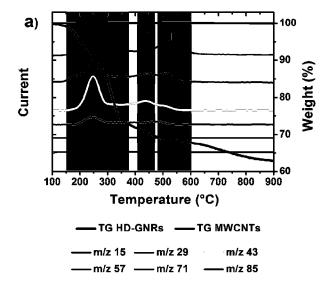


FIG. 10



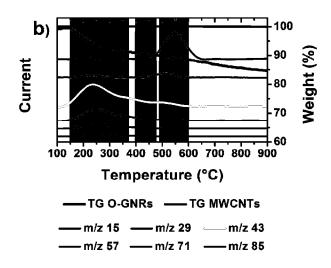


FIG. 11

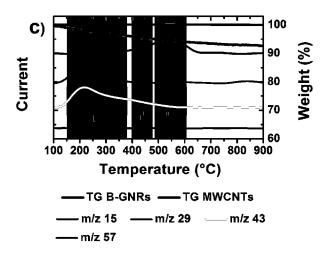


FIG. 11

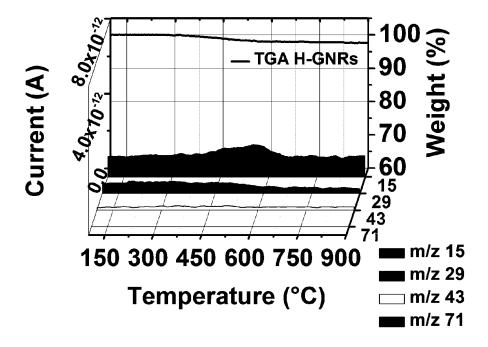
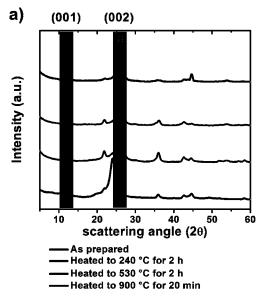


FIG. 12



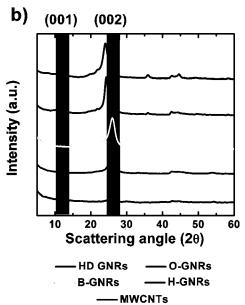


FIG. 13

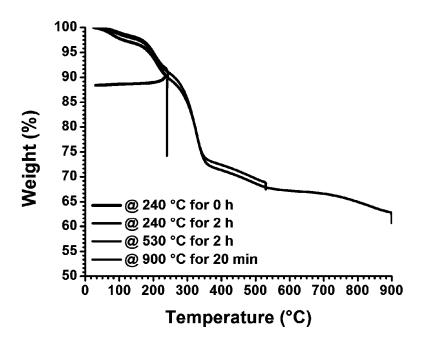


FIG. 14

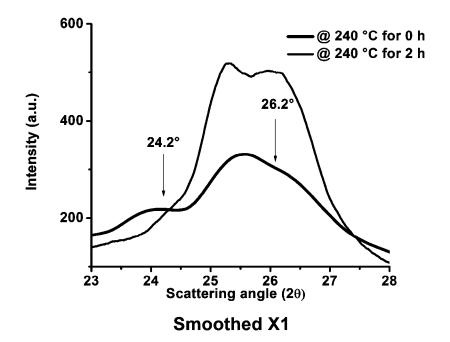


FIG. 15

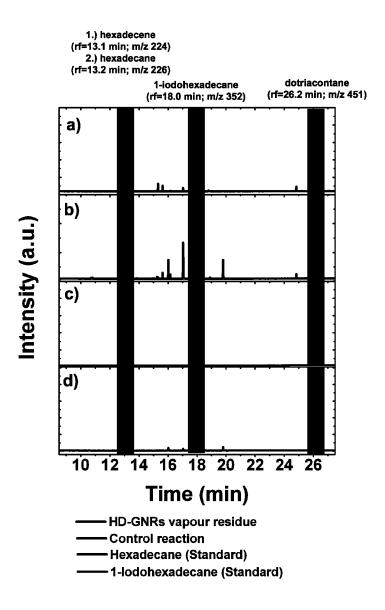
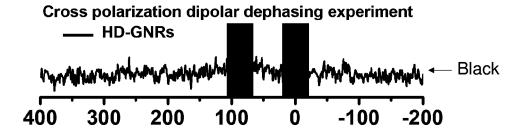


FIG. 16



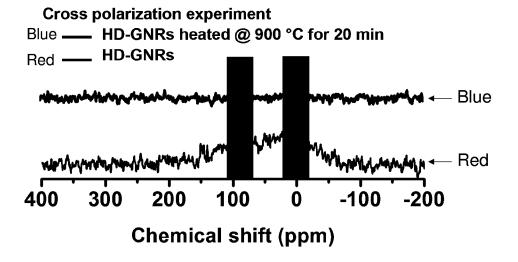
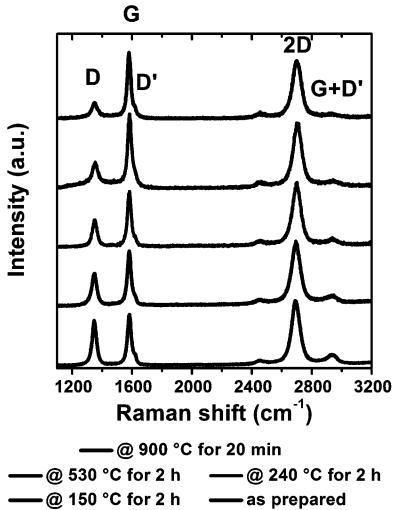


FIG. 17



-@ 150 °C for 2 h

FIG. 18

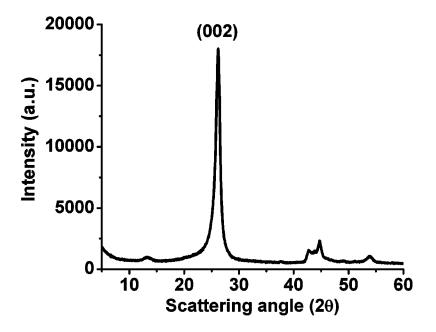


FIG. 19

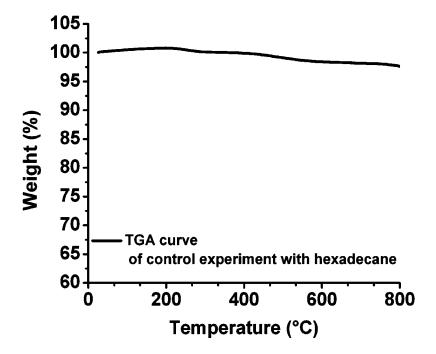


FIG. 20

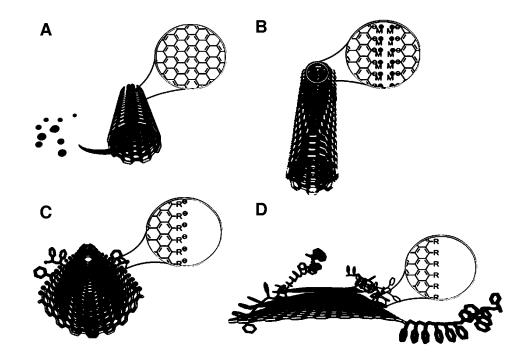
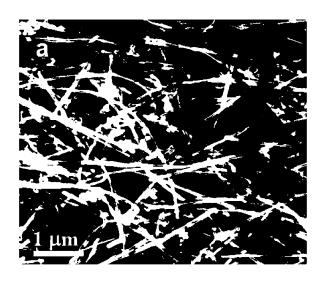
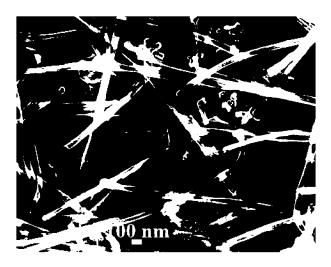


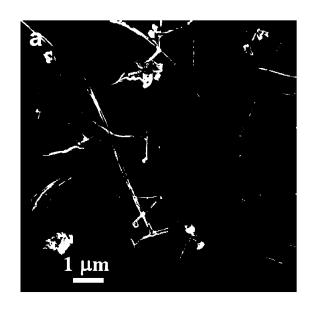
FIG. 21







В



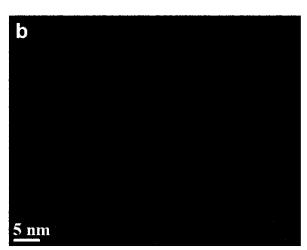
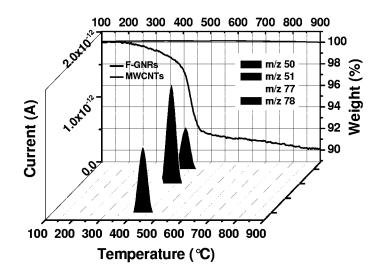


FIG. 24





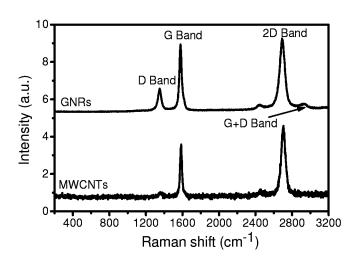
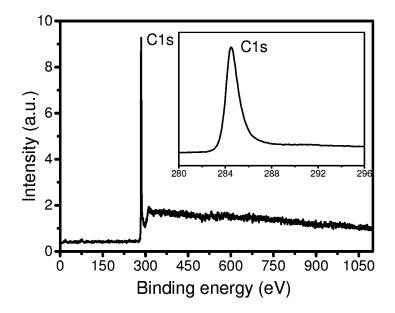
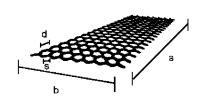


FIG. 26



C



F = Functional Group
C = Carbon
n _{C(edges) =} n _{F(edges)}

	value	unit
a	3000	nm
b	150	nm
d	0.246	nm
S	0.142	nm
M _(c)	12	g/mol
M _(F)	104.15	g/mol
Weight loss % obtained by TGA (between 384 °C and 474 °C)	6	%

	value	unit
N _{C(all)}	29,744,200	#atoms
n _{C(all)}	4.94E-17	mol
m _{C(all)}	5.93E-16	g

	value	unit
N _{C(edges)}	25,610	#atoms
n _{C(edges)}	4.25E-20	mol
m _{C(edges)}	5.10E-19	g

atomic % of the edges	0.09
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	value	unit
n _{F (TGA})	0.057609217	mol
n _{C (all TGA)}	7.833333333	g

	Ratio of	
nomer nits	n _{C (all TGA):}	136 :1
HILS	n _{F(TGA)}	

Ratio of	
n _{C (all):}	
$n_{c(edges)}$	1161 :1

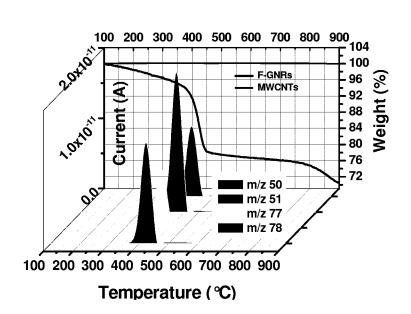
value unit

Average length of the polymer chain on the edges units

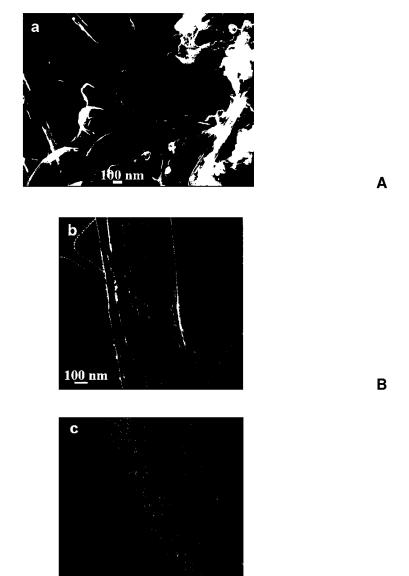




В



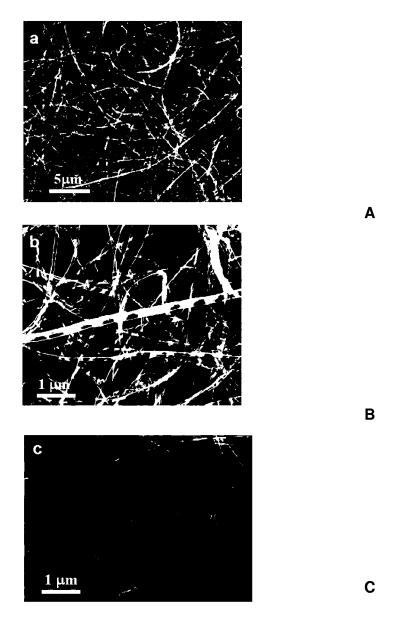
C

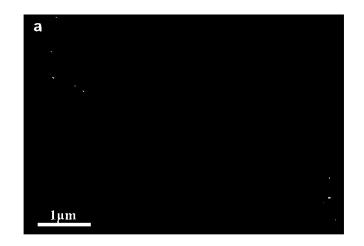


2<u>n</u>m

FIG. 29

C





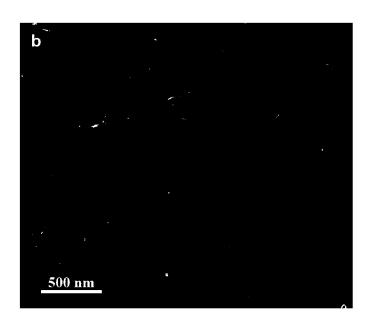
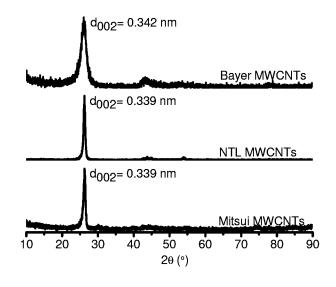


FIG. 31



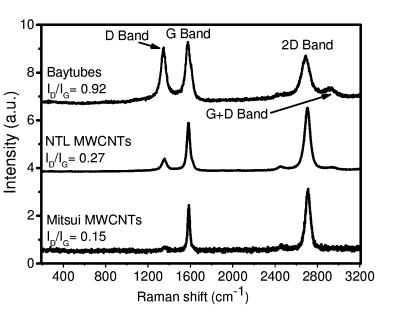
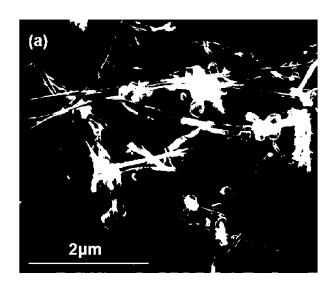


FIG. 32

Α



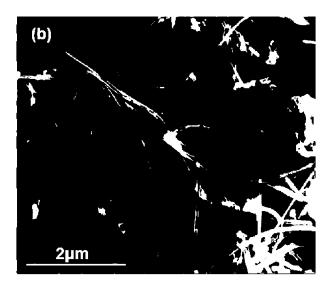
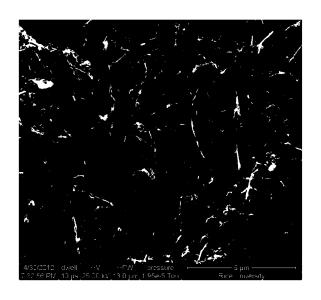


FIG. 33



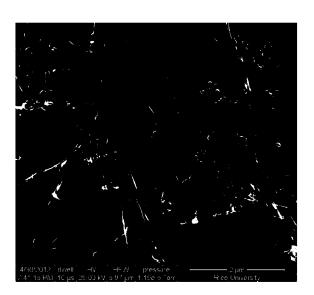
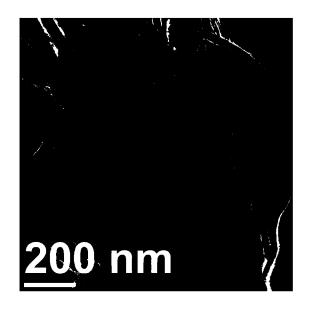
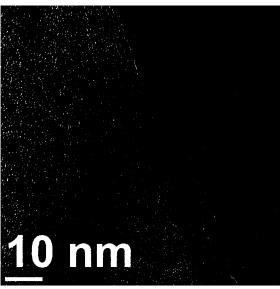


FIG. 34







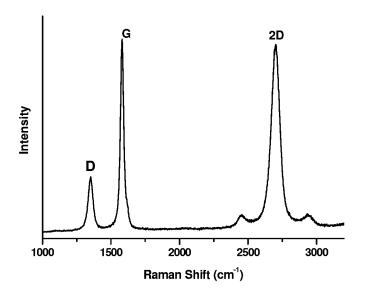


FIG. 36