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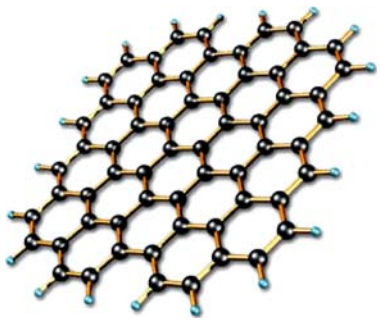
摘要 石墨烯是2004年才被发现的一种新型二维平面纳米材料, 其特殊的单原子层结构决定了它具有丰富而新奇的物理性质. 过去几年中, 石墨烯已经成为了备受瞩目的国际前沿和热点. 在石墨烯的研究和应用中, 为了充分发挥其优良性质, 并改善其成型加工性(如分散性和溶解性等), 必须对石墨烯进行功能化, 研究人员也在这方面开展了积极而有效的工作. 但是, 关于石墨烯的功能化方面的研究还处在探索阶段, 对各种功能化的方法和效果还缺乏系统的认识. 如何根据实际需求对石墨烯进行预期和可控的功能化是我们所面临的机遇和挑战. 本文重点阐述了石墨烯的共价键和非共价键功能化领域的最新进展, 并对功能化石墨烯的应用作了介绍, 最后对相关领域的发展趋势作了展望.

关键词
石墨烯
共价键
非共价键
功能化
应用

1

, ,
. 20 ,
, 1985 [1] 1991
[2] . 2004
, sp^2
- (Graphene)[3],
(1), .
, ,

,
. 2004 ,
SCI 2000 ,
[4~8].



1 [4]

, ,
0.35 nm.
, . ,
[9], 130 GPa,
100 ; 15000 $cm^2 \cdot V^{-1} \cdot s^{-1}$[10],
,

10 , (

),   250000

$cm^2·V^{-1}·s^{-1}$[7];   5000 $W·m^{-1}·K^{-1}$,

3 [11];   [12]

[13] . ,

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, 21

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[3] [14]

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[15] [16] [17]

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2

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, ,

(Graphene oxide).

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2.1

2006 , Stankovich

[18], ,

,

(2).

N,*N*- (DMF)

, .

, ( ), ,

.

, Haddon

, (ODA)

, .

0.3~0.5 nm,

(THF) [19].

, , π

, .

, Samulski

.

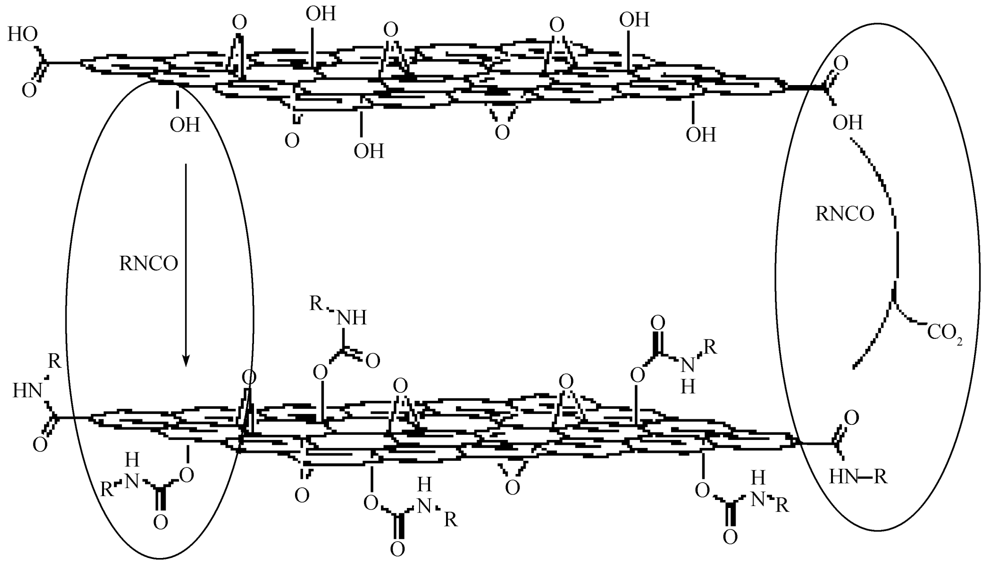
, , , ,

, [20].

, ,

(1250 S/m), ,

, , .



2 [18]

2.2

, .

, , PS-PAM

, , ,

. .

, Ye

[21]. 3 ,

2.3

, ,

, , , , ,

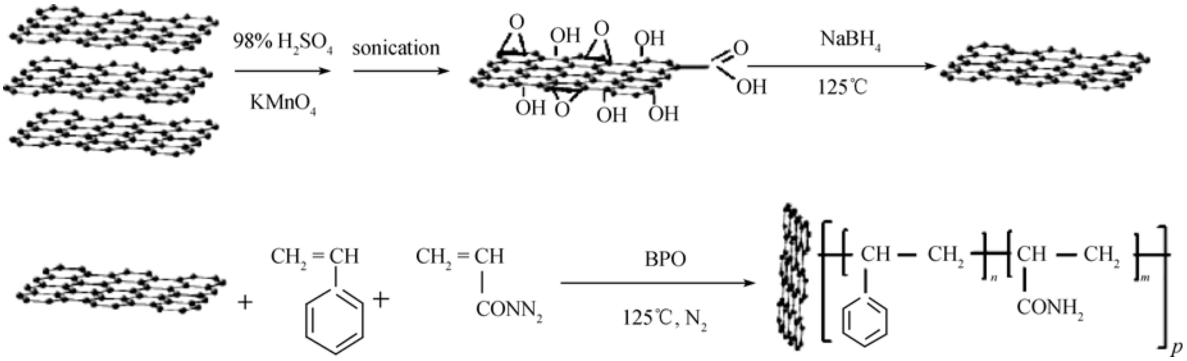
(BPO) , . Chen

, [22].

- (PS-PAM) , ,

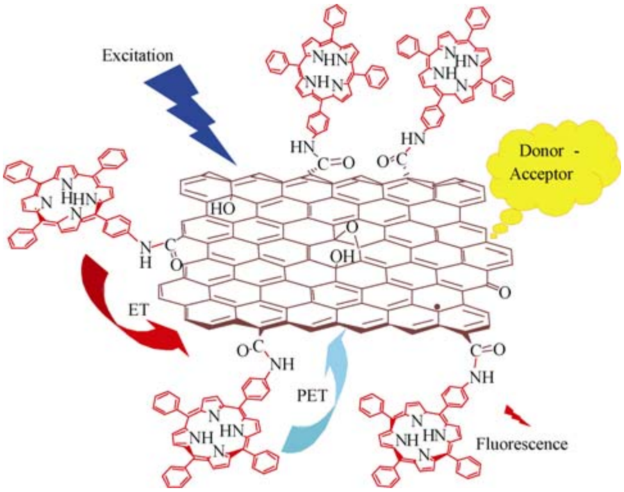
. (TPP) ,

, - (Donor-



3 [21]

Acceptor) - (4).
,
, .
C60 ,
[23,24].



4 - (-) [22]

Chen (Fe_3O_4)
[25].
, ;
, ;
, - .
,
, ,
, 2~4
nm . ,
.

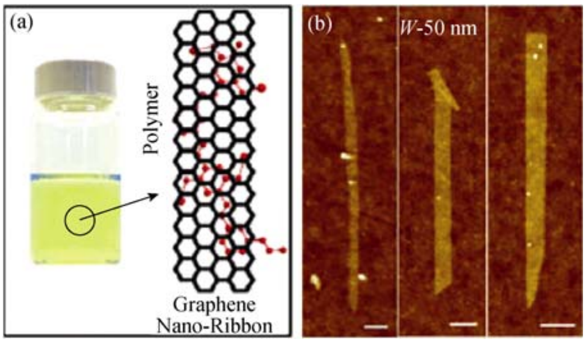
3

, π-π
,
, .

3.1 π

,
,

. ,
, ,
, ,
. ,
, (SDS)
TRITON(X-100) ,
. Ruoff
(PSS) ,
, PSS ,
,
(1 mg/mL)[26].
PmPV π , Dai
PmPV π-π ,
PmPV [27].
PmPV ,
PmPV ,
(5).



5 PmPV [27]

, Shi
, π-π ,
,
[28]. (3,4-)(PEDOT)
,
,
[29].

3.2

. Penicaud [30].

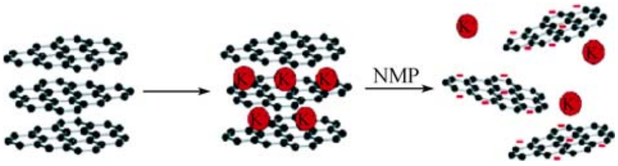
( ) ,

N- (NMP) .

,

,

(6).



6 [30]

Li [31]. ,

, ,

,

. , ,

,

,

.

, Mullen , [32].

( ), ( ),

, .

, ,

,

.

3.3

,

,

, ,

.

,

. Chen

[33].

,

,

, 1 , PH ,

.

1 PH [33]

pH	GO	DXR
2	–OH , –COOH	–OH
7	–OH , –COOH	–OH, $–NH_2$
10	–OH	–OH, $–NH_2$

Mann DNA

, [34].

,

DNA, , DNA

. 0.5~2.5 mg/mL,

; DNA ,

, .

DNA .

4

,

, ,

,

.

4.1

.

, ,

,

. Ruoff -

, [15].

, ,

,

0.1%.

Brinson -

,

,

; 1% ,

40 ,

[35].

Chen

(TPU) ,

(Infrared-Triggered Actuators) [36]. , 1 wt%

, TPU 75%,

120%. ,

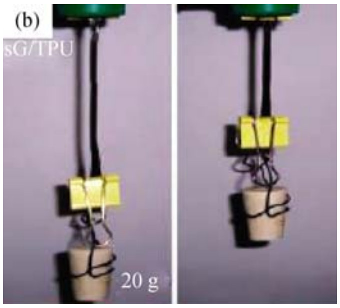
. 7 ,

, 21.6 g

3.1 cm. , 10 ,

,

, .



7 [36]

4.2

. ,

.

,

. Chen

( )

[22]. ,

C60(

) ,

,

.

(FET)

,

FET . Dai PmPV

[27], 50~10 nm ,

. ,

10 nm , ,

FET,

10^7.

Chen

(SPFGraphene)

[37~39]. 80%

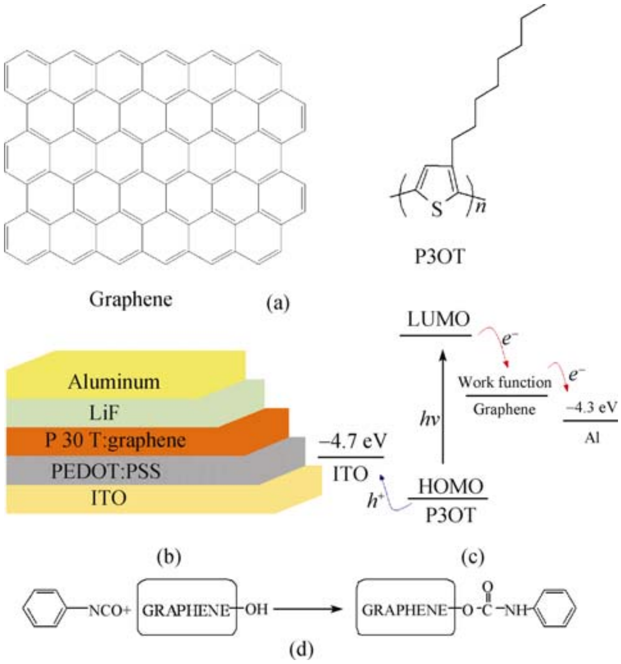
, ~10^2 /square,

;

SPFGraphene ,

,

1.4%(8).



8 [38]

4.3

,

, . Dai ,
, , (
,).
; π-π ,
(SN38) [40], , .
. , ;
Chen , ;
, (DXR)
[34]. , ;
DXR 2.35 mg/mg, ,
([41], [42] . ,
[43] 1 mg/mg). , ( ) (
pH ,) ,
. , DXR (
, , ,)
pH . , ( )
, ,
[25]. DXR . ,
1.08 mg/mg, . π (
,)
, (
. ,)
,
, π-π ,
.
, .

4 , 2004 ,
, , ,
. .
, ,
. ,
, ,
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; , .

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Functionalization of Graphene and Their Applications

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Abstract: Graphene a flat monolayer of carbon atoms tightly packed into a two dimensional honeycomb lattice—was discovered in 2004. Due to its unusual molecular structure, grapheme shows many novel and unique physical and chemical properties, which are generating much attention in both the communities of science and industry. To materialize many of the prospect applications, the key is to functionalize graphene in a controlled way to achieve desired properties, such as enhanced solution processing capability, and at the same time maintain the intrinsic properties of graphene at maximum level. So in this review, we present the current status in the studies for the functionalization of graphene. Particularly, the covalent and noncovalent functionalizations of graphene are summarized. Also, the related applications using these functionalized graphene materials have been briefly introduced.

Keywords: graphene, covalent, noncovalent, functionalization, applications