## Metal Dimer Nanojunctions Composites with Magnetic Materials for Magnetic Field Sensing

Gang-Yi Chen and Su-Wen Hsu\*

Department of Chemical Engineering, National Cheng Kung University, Taiwan

No. 1 University Road, East Dist., Tainan City 70101, Taiwan (R.O.C)

\*E-mail: swhsu@gs.ncku.edu.tw



Figure S1 Experimental setup for measurement the Raman spectra of dimer nanojunctions composite under different directions of the external magnetic force. (A) y-axis magnetic field: magnetic field parallel to the substrate; (B) z-axis magnetic field: magnetic field perpendicular to the substrate.

**Table S1** Enhancement factors of Raman signals (different vibration modes) of vertical dimer nanojunctions composite with naphthalenediamine under external magnetic field (parallel or perpendicular to the substrate).

	Chomical chift (cm <sup>-1</sup> )/vibration mode	Enh	ancement factor	$(EF) = (I' - I_0) / I_0$ (%)		
		y-a	axis	z-axis		
Naphthalenediamine	1358 C-N stretching	485.4	507 4 + 21 1	128.5	129 2   12 7	
(NDA)	1594 N-H deformation vibration	529.4	507.4 ± 51.1	148.0	138.3 <u>+</u> 13.7	
DC	1450 CH <sub>2</sub> scissoring	528.8	591 2 1 74 2	226.3	205.8   20.1	
P3	1615 Ring-skeletal stretch	633.7	581.3 ± 74.2	185.2	203.0 ± 29.1	
	1327 C-N stretching / CH <sub>2</sub> wagging	505.6		204.9		
РVР	1501 C-N stretching	527.1	534.9 ± 33.8	204.9	270.6 ± 113.7	
	1760 C=O stretching	571.8		401.9		

**Table S2** Enhancement factors of Raman signals (different vibration modes) of horizontal dimer nanojunctions composite with naphthalenediamine under external magnetic field (parallel or perpendicular to the substrate).

	Chamical shift (sm <sup>-1</sup> ) (vibration mode	Enh	ancement factor	$(EF) = (I' - I_0) / I_0$ (%)		
	Chemical shift (chi =)/vibration mode	у-а	axis	z-axis		
Naphthalenediamine	1358 C-N stretching	723.4	699 2 1 52 6	168.1	1667 1 2 00	
(NDA)	1594 N-H deformation vibration	649.0	088.2 ± 52.0	165.2	$100.7 \pm 2.09$	
DS	1450 CH <sub>2</sub> scissoring	654.8	7447 + 1272	202.8	182.2 ± 29.1	
P3	1615 Ring-skeletal stretch	834.7	/44./ ± 12/.2	161.7		
	1327 C-N stretching / CH <sub>2</sub> wagging	723.4		202.5		
PVP	1501 C-N stretching	669.2	$\] 771.6 \pm 133.2$	222.1	205.2 $\pm$ 15.7	
	1760 C=O stretching	922.1		191.0		

**Table S3** Enhancement factors of Raman signals (different vibration modes) of vertical dimer nanojunctions composite with benzimidazole under external magnetic field (parallel or perpendicular to the substrate).

	Chomical chift (cm <sup>-1</sup> )/vibration mode	Enh	ancement factor	$(EF) = (I' - I_0) / I_0$ (%)		
		y-a	ixis	z-axis		
Benzimidazole	1265 (C-H) in-plane bending	204.6	224 5 1 27 6	566.1	506 5   42 1	
(BIM)	1595 N-H deformation vibration	244.0	$224.5 \pm 27.6$	626.7	590.5 ± 43.1	
DC	1450 CH <sub>2</sub> scissoring	187.3	170.0 + 11.2	543.6	509 5 ± 7 1	
F3	1615 Ring-skeletal stretch	171.8	179.0 ±11.5	652.8	57 <b>6.</b> 5 ± 7.1	
	1327 C-N stretching / CH <sub>2</sub> wagging	231.3		452.8		
PVP	1501 C-N stretching	166.1	160.7±88.6	760.8	546.0 ± 186.7	
	1760 C=O stretching	097.4		424.4		

**Table S4** Enhancement factors of Raman signals (different vibration modes) of horizontal dimer nanojunctions composite with benzimidazole under external magnetic field (parallel or perpendicular to the substrate).

	Chamical shift (cm <sup>-1</sup> ) (vibration mode	Enh	ancement factor	$(EF) = (I' - I_0) / I_0$ (%)		
	Chemical shift (cm -)/vibration mode	у-а	axis	z-axis		
Benzimidazole	1265 (C-H) in-plane bending	747.1	694.0 + 90.2	881.4	702.0 \ 252.4	
(BIM)	1595 N-H deformation vibration	621.0	084.0 ± 89.2	524.4	/02.9 ± 252.4	
DC	1450 CH <sub>2</sub> scissoring	638.9	714.0 + 107.6	861.7	750 8 + 144 1	
P3	1615 Ring-skeletal stretch	791.0	/14.9 ± 107.0	657.9	737.0 <u>r</u> 144.1	
	1327 C-N stretching / CH <sub>2</sub> wagging	577.0		758.5		
РVР	1501 C-N stretching	842.8	$558.7 \pm 293.7$	1133.9	722.4 ± 430.7	
	1760 C=O stretching	256.3		274.7		

**Table S5** Enhancement factors of Raman signals (different vibration modes) of vertical dimer nanojunctions composite with different naphthalenediamine concentrations under external magnetic field (parallel or perpendicular to the substrate).

		Chemical shift (cm <sup>-1</sup> )/vibration mode	Enh	ancement factor	$(EF) = (I' - I_0)/I_0$	, (%)	
			y-a	axis	z-a	ixis	
	High conc	1358 C-N stretching	485.4	507 4 + 21 1	128.5	129 2   12 7	
Naphthalene	nigh conc.	1594 N-H deformation vibration	529.4	507.4 <u>+</u> 51.1	148.0	138.3 <u>+</u> 13.7	
(NDA)	low cone	1358 C-N stretching	289.6	260.1 + 28.0	138.4	110.8   26.2	
	low conc.	1594 N-H deformation vibration	248.7	209.1±28.9	101.3	119.8 ± 20.3	
High conc.		1450 CH <sub>2</sub> scissoring	528.8	591 2 1 74 2	226.3	205.8 + 20.1	
PS	nigh conc.	1615 Ring-skeletal stretch	633.7	561.5 <u>+</u> 74.2	185.2	203.0 1 27.1	
	low cons	1450 CH <sub>2</sub> scissoring	267.3	266 0 1 0 64	122.0	114.2   10.0	
	low conc.	1615 Ring-skeletal stretch	266.4	200. 9 $\pm$ 0.04	106.5	114.2 ± 10.9	
		1327 C-N stretching / CH <sub>2</sub> wagging	505.6		204.9		
	High conc.	1501 C-N stretching	527.1	534.9 ± 33.8	204.9	270.6 ± 113.7	
DV/D		1760 C=O stretching	571.8		401.9		
PVP –		1327 C-N stretching / CH <sub>2</sub> wagging	268.0		120.9		
	low conc.	1501 C-N stretching	226.5	$252.5 \pm 22.7$	84.7	99.6±18.9	
		1760 C=O stretching	262.9		931.4		

**Table S6** Enhancement factors of Raman signals (different vibration modes) of horizontal dimer nanojunctions composite with different naphthalenediamine concentrations under external magnetic field (parallel or perpendicular to the substrate).

		Chemical shift (cm <sup>-1</sup> )/vibration mode	Enh	ancement factor	$(EF) = (I' - I_0)/I_0$	, (%)	
		chemical shift (chi )/vibration mode	y-a	axis	z-a	ixis	
	High conc	1358 C-N stretching	723.4	688 2 1 52 6	168.1	1667   2.00	
Naphthalene	nigh conc.	1594 N-H deformation vibration	649.0		165.2	$100.7 \pm 2.09$	
(NDA)	low conc	1358 C-N stretching	244.2	202.0 ± 67.6	93.2	112.0 ± 26.6	
		1594 N-H deformation vibration	339.8	292.0 ± 07.0	130.8	112.0 <u>±</u> 20.0	
	High conc	1450 CH <sub>2</sub> scissoring	528.8	591 2 + 74 2	226.3	205 8 ± 20 1	
PS		1615 Ring-skeletal stretch	633.7	561.5 <u>+</u> 74.2	185.2	203.0 ± 29.1	
	low conc	1450 CH <sub>2</sub> scissoring	245.6	252 7 + 11 4	108.9	121 0 + 10 2	
	low conc.	1615 Ring-skeletal stretch	261.7	233.7 ± 11.4	134.7	121:0 - 10:2	
		1327 C-N stretching / CH <sub>2</sub> wagging	505.6		204.9		
	High conc.	1501 C-N stretching	527.1	534.9 ± 33.8	204.9	270.6 $\pm$ 113.7	
D\/D		1760 C=O stretching	571.8		401.9		
PVP —		1327 C-N stretching / CH <sub>2</sub> wagging	251.1		111.0		
	low conc.	1501 C-N stretching	278.4	$\begin{array}{ c c c c c c } 272.6 \pm 19.2 \end{array}$	117.8	107.6 ±12.2	
		1760 C=O stretching	288.2		94.1		

**Table S7** Enhancement factors of Raman signals (different vibration modes) of vertical dimer nanojunctions composite with different benzimidazole concentrations under external magnetic field (parallel or perpendicular to the substrate).

		Chemical shift (cm <sup>-1</sup> )/vibration mode	Enh	ancement factor	$(EF) = (I' - I_0)/I_0$	) (%)	
			у-а	axis	z-a	ixis	
	High conc	1265 (C-H) in-plane bending	204.6	2245 1 276	566.1	506 5 1 42 1	
Benzimidazole	nigh conc.	1595 N-H deformation vibration	244.0	$224.5 \pm 27.0$	626.7	590.5 ± 43.1	
(BIM)	low conc	1265 (С-Н) in-plane bending	184.9	1645 + 276	229.5	25674295	
	low conc.	1595 N-H deformation vibration	145.9	104.5 ± 27.0	284.0	230.7±38.5	
Uich cons		1450 CH <sub>2</sub> scissoring	187.3	170.0 ±11.3	543.6	508 5 ± 7 1	
PS		1615 Ring-skeletal stretch	171.8	179.0 <u>+</u> 11.5	652.8	<u>576.5 T</u> 7.1	
	low conc	1450 CH <sub>2</sub> scissoring	180.9	147.0 ± 46.7	454.2	422 8 + 44 4	
	low conc.	1615 Ring-skeletal stretch	114.1	147.0 ± 40.7	391.5		
		1327 C-N stretching / CH <sub>2</sub> wagging	231.3		452.8		
	High conc.	1501 C-N stretching	166.1	160.7 <u>+</u> 88.6	760.8	546.0 ± 186.7	
D\/D		1760 C=O stretching	097.4		424.4		
PVP —		1327 C-N stretching / CH <sub>2</sub> wagging	118.9		568.0		
	low conc.	1501 C-N stretching	165.9	$\boxed{129.3\pm31.6}$	485.7	414.6 ± 198.7	
		1760 C=O stretching	105.9		190.2		

**Table S8** Enhancement factors of Raman signals (different vibration modes) of horizontal dimer nanojunctions composite with different benzimidazole concentrations under external magnetic field (parallel or perpendicular to the substrate).

		Chemical shift (cm <sup>-1</sup> )/vibration mode	Enh	ancement factor	$(EF) = (I' - I_0)/I_0$	, (%)	
			y-a	axis	z-a	ixis	
	High conc	1265 (C-H) in-plane bending	747.1	684.0 + 80.2	881.4	702.0 + 252.4	
Benzimidazole	High conc.	1595 621.0 N-H deformation vibration		684.0 ± 89.2	524.4	702.9 <u>+</u> 232.4	
(BIM)	low conc	1265 (С-Н) in-plane bending	157.0	226.0 ± 07.6	430.0	491 9 ± 72 2	
		1595 N-H deformation vibration	295.1	220.0 ± 97.0	533.7	481.8 ± 73.3	
Uish cons		1450 CH <sub>2</sub> scissoring	638.9	$714.9 \pm 107.6$	861.7	750 9 ± 144 1	
PS		1615 Ring-skeletal stretch	791.0	/14.9 ± 107.0	657.9	7 <b>39.0</b> <u>+</u> 144.1	
	low conc	1450 CH <sub>2</sub> scissoring	199.6	222.2 + 47.5	403.4	512 2 ± 155 4	
	low conc.	1615 Ring-skeletal stretch	266.8	233.2 <u>1</u> 47.3	623.2		
		1327 C-N stretching / CH <sub>2</sub> wagging	577.0		758.5		
	High conc.	1501 C-N stretching	842.8	$558.7 \pm 293.7$	1133.9	722.4 $\pm$ 430.7	
D\/P		1760 C=O stretching	256.3		274.7		
PVP —		1327 C-N stretching / CH <sub>2</sub> wagging	224.5		462.9		
	low conc.	1501 C-N stretching	306.5	$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	528.6	450.4 ± 85.1	
	-	1760 C=O stretching	350.3		359.8		



Figure S2 Raman spectra of vertical dimer nanojunctions composite with naphthalenediamine under different strengths of the external magnetic force. The strength of the magnetic force applied on the composite can be tuned by changing the spacing between the composite and the magnetic source (magnetic bar). Raman spectra of nanocomposites with two different morphologies of dimer nanojunctions, vertical and horizontal dimer nanojunctions, are shown in (A) and (B), respectively.  $\Box$ 

						Enhan	cement factor	$(EF) = (I' - I_0)$	)/I <sub>0</sub> (%)				
	Chemical shift (cm <sup>-1</sup> ) /vibration mode	Spacing =1 cm				Spacing =2 cm			Spacing =3 cm				
	,	y.	y-axis z-axi		z-axis	y-axis		z-axis		y-axis		z-axis	
Naphthalene	1358 C-N stretching	485.4	507 4 + 31 1	128.5		155.7	170 4 4 00 5	61.0		63.7	60 6 1 6 0	28.1	
(NDA) 1594 N-H deformation vibration	529.4	$-507.4 \pm 31.1$	148.0	138.3 ± 13.7	189.0	172.4 ± 23.5	45.9	53.5 ±10.7	73.5	68.6 ± 6.9	39.3	33.7 ± 7.9	
	1450 CH <sub>2</sub> scissoring	528.8	591 2 1 74 2	226.3	- 205.8 ± 29.1	148.1		106.6		65.4	<b>50 5 1 30 5</b>	56.5	· 49.3 ± 10.2
P5	1615 Ring-skeletal stretch	633.7	$-581.3 \pm /4.2$	185.2		190.7	169.4 ± 30.1	48.4	77.5 ± 41.1	94.1	79.7 ± 20.2	42.1	
	1327 C-N stretching / CH <sub>2</sub> wagging	505.6		204.9		176.8		81.2		47.3		55.3	
PVP	1501 C-N stretching	527.1	534.9 ± 33.8	204.9	270.6 ± 113.7	173.0	188.2 ± 23.2	86.7	125.5 ± 72.0	68.3	52.0 ± 14.5	46.1	57.9 ± 13.2
	1760 C=O stretching	571.8		401.9	1	214.9	1	208.6		40.6		72.2	

**Table S9** Enhancement factors of Raman signals (different vibration modes) of vertical dimer nanojunctions composite with naphthalenediamine under different strengths of the external magnetic force.



Figure S3 Raman spectra of horizontal dimer nanojunctions composite with naphthalenediamine under different strengths of the external magnetic force. The strength of the magnetic force applied on the composite can be tuned by changing the spacing between the composite and the magnetic source (magnetic bar). Raman spectra of nanocomposites with two different morphologies of dimer nanojunctions, vertical and horizontal dimer nanojunctions, are shown in (A) and (B), respectively.

**Table S10** Enhancement factors of Raman signals (different vibration modes) of horizontal dimer nanojunctions composite with naphthalenediamine under different strengths of the external magnetic force.

						Enhance	ment factor (	$EF) = (I' - I_0)$	/I <sub>0</sub> (%)				
	Chemical shift (cm <sup>-1</sup> ) /vibration mode		Spacing	=1 cm			Spacing =2 cm			Spacing =3 cm			
	,	у	y-axis z-axis		axis	y-axis		z-axis		y-axis		z-axis	
Naphthale	1358 C-N stretching	723.4	168.1 688.2 ± 52.6	168.1	1667 1 2 00	263.6	151.7 ± 10.0-	101.3	1015   0.2	88.6	80.4   1.1	51.0	- 49.9 ± 1.5
(NDA)	1594 N-H deformation vibration	649.0	668.2 ± 52.6	165.2	166.7 ± 2.09	227.3		101.7	101.5 ± 0.3	90.2	89.4 ± 1.1	48.8	
DE	1450 CH <sub>2</sub> scissoring	654.8	744 7 + 127 2	202.8	-182.2 ± 29.1	227.4	103.4± 77.5	98.8	04.2 + 6.2	54.3	0441568	74.3	- 53.3 ± 29.6
PS —	1615 Ring-skeletal stretch	834.7	744.7 ± 127.2	161.7		343.1		89.8	94.3 ± 0.3	134.6	94.4 ± 50.8	32.4	
	1327 C-N stretching / CH <sub>2</sub> wagging	723.4		202.5		259.6		115.3		34.6		60.3	
PVP	1501 C-N stretching	669.2	771.6 ± 133.2	222.1	205.2 ± 15.7	204.6	128.8 ± 30.6	163.2	125.3 ± 34.0	34.2	73.7 ± 68.2	71.0	48.9 ± 29.5
	1760 C=O stretching	922.1		191.0		430.4		97.4		152.5	1	15.4	



Figure S4 Raman spectra of vertical dimer nanojunctions composite with benzimidazole under different strengths of the external magnetic force. The strength of the magnetic force applied on the composite can be tuned by changing the spacing between the composite and the magnetic source (magnetic bar). Raman spectra of nanocomposites with two different morphologies of dimer nanojunctions, vertical and horizontal dimer nanojunctions, are shown in (A) and (B), respectively.

5	1		8 8										
						Enhancement factor (EF) = $(I'-I_0)/I_0$ (%)							
	Chemical shift (cm <sup>-1</sup> ) /vibration mode		Spacin	g =1 cm			Spacing	g =2 cm			Spacing =3 cm		
		y-:	axis	z-axis		y-axis		z-axis		y-axis		z-a	ixis
Benzimidazole	1265 (С-Н) in-plane bending	204.6	224 5 + 27 6	566.1	50(5   421	5 ± 43.1 197.7 80.5	138.5 ± 82.7	34.9	212.0 1 20.0	85.6	(4.0.   20.7	69.7	64.5± 6.4
(BIM)	1595 N-H deformation vibration	244.0	224.5 ± 27.0	626.7 596.3	590.5 ± 43.1			284.1	312.0 ± 39.6	43.2	64.0 ± 29.7	60.2	
DC	1450 CH <sub>2</sub> scissoring	187.3	170.0 + 11.2	9.0 ±11.3 652.8	543.6 552.8 598.5 ± 7.1	117.0	100 5 1 10 0	242.9	264.0 + 21.1	28.2	42.5 1 21.0	42.1	· 61.5 ± 27.6
P3	1615 Ring-skeletal stretch	171.8	1/9.0 ±11.3			100.2	108.5 ± 12.0	286.4	204.0 ± 51.1	59.1	43.5 ± 21.9	81.1	
	1327 C-N stretching / CH <sub>2</sub> wagging	231.3		452.8		209.8		282.0		67.8		90.3	
PVP	1501 C-N stretching	166.1	160.7±88.6	760.8	546.0 ± 186.7	110.5	122.3 ± 81.2	277.2	265.3 ± 24.7	37.7	58.0 ± 18.2	73.6	59.3 ± 39.3
	1760 C=O stretching	097.4		424.4		048.3		237.9	1	70.2	1	15.4	

 Table S11 Enhancement factors of Raman signals (different vibration modes) of vertical dimer nanojunctions composite with benzimidazole under different strengths of the external magnetic force.



Figure S5 Raman spectra of horizontal dimer nanojunctions composite with benzimidazole under different strengths of the external magnetic force. The strength of the magnetic force applied on the composite can be tuned by changing the spacing between the composite and the magnetic source (magnetic bar). Raman spectra of nanocomposites with two different morphologies of dimer nanojunctions, vertical and horizontal dimer nanojunctions, are shown in (A) and (B), respectively.

						Enhanc	ement factor	$(EF) = (I' - I_0)$	)/I <sub>0</sub> (%)				
	Chemical shift (cm <sup>-1</sup> ) /vibration mode		Spacing	g =1 cm		Spacing =2 cm				Spacing =3 cm			
		y-axis		z-axis		y-axis		z-axis		y-axis		z-axis	
Benzimidazole	1265 (С-Н) in-plane bending	747.1	684.0 + 89.2	881.4	702.0 + 252.4	298.7	-278.5 ± 28.6	93.3	241.0 1.4.2	238.5	70.4   10.7	127.2	112 7 1 20 5
(BIM)	1595 N-H deformation vibration	621.0	684.0 ± 89.2	524.4	102.9 ± 232.4	258.3		65.5	241.0 ± 4.2	244.2	/9.4 ± 19.7	98.1	112.7 ± 20.5
DC	1450 CH <sub>2</sub> scissoring	638.9	714.9 ± 107.6 657.9	861.7	.7 759.8 ± 144.1	258.4	204.1 1 50.4	87.5	100 5 1 22 2	174.0	00 2 1 1 1	98.7	·132.2 ± 47.5
PS -	1615 Ring-skeletal stretch	791.0		657.9		329.7	294.1 ± 50.4	89.0	190.5 ± 23.3	207.4	88.2± 1.1	165.8	
	1327 C-N stretching / CH <sub>2</sub> wagging	577.0		758.5		284.2		88.0		207.9		182.8	
PVP	1501 C-N stretching	842.8	558.7 ± 293.7	1133.9	722.4 ± 430.7	354.2	268.6 ± 94.3	116.8	199.7 ± 91.2	287.2	81.5 ± 39.0	134.2	137.8 ± 43.3
	1760 C=O stretching	256.3		274.7	1	167.5	1	39.6	1	105.7		9.6	

Table S12 Enhancement factors of Raman signals (different vibration modes) of horizontal dimer nanojunctions composite with benzimidazole under different strengths of the external magnetic force.



**Figure S6 Raman spectra of vertical dimer nanojunctions composite with half the concentration of naphthalenediamine under different strengths of the external magnetic force.** The strength of the magnetic force applied on the composite can be tuned by changing the spacing between the composite and the magnetic source (magnetic bar). Raman spectra of nanocomposites with two different morphologies of dimer nanojunctions, vertical and horizontal dimer nanojunctions, are shown in (A) and (B), respectively.

						Enhan	cement factor	(EF) = $(I' - I_0)$	)/I <sub>0</sub> (%)				
	Chemical shift (cm <sup>-1</sup> ) /vibration mode		Spacin	ıg =1 cm			Spacing	g =2 cm			Spacing	g =3 cm	
	,	у-	axis	Z-á	axis	y-a	axis	z-a	ixis	y-a	ixis	z-a	ixis
Naphthalene	1358 C-N stretching	289.6	260.1 + 28.0	138.4	110.0 1 0 0 0	118.7	1000	66.5	57.0 1 12.2	90.0	77.1.1.10.2	26.1	
(NDA)	1594 N-H deformation vibration	248.7	269.1± 28.9	101.3	$119.8 \pm 26.3$	118.5	118.6 ± 0.2	49.1	57.8 ± 12.3	64.1	77.1 ± 18.3	14.6	20.3 ± 8.1
DC	1450 CH <sub>2</sub> scissoring	267.3	266.0 + 0.6	122.0	114.2 1 10.0	106.5	120.0   21.0	71.5	71.0 1.0 20	70.4	(8.8.1.2.2	16.2	17 (   2.0
PS	1615 Ring-skeletal stretch	266.4	200. 9 ± 0.0	106.5	$114.2 \pm 10.9$	151.5	129.0 ± 31.8	72.0	71.8 ± 0.30	67.2	68.8 ± 2.2	19.0	17.6 ± 2.0
	1327 C-N stretching / CH <sub>2</sub> wagging	268.0		120.9		103.1		61.5		74.2		21.9	
PVP	1501 C-N stretching	226.5	252.5± 22.7	84.7	99.6±18.9	87.9	88.5 ± 14.2	58.7	59.3 ± 2.0	57.6	56.0 ± 19.1	18.8	20.5 ± 1.6
	1760 C=O stretching	262.9		931.4		74.7		57.6		0.00		21.0	

**Table S13** Enhancement factors of Raman signals (different vibration modes) of vertical dimer nanojunctions composite with half the concentration of naphthalenediamine under different strengths of the external magnetic force.



Figure S7 Raman spectra of horizontal dimer nanojunctions composite with half the concentration of naphthalenediamine under different strengths of the external magnetic force. The strength of the magnetic force applied on the composite can be tuned by changing the spacing between the composite and the magnetic source (magnetic bar). Raman spectra of nanocomposites with two different morphologies of dimer nanojunctions, vertical and horizontal dimer nanojunctions, are shown in (A) and (B), respectively.  $\Box$ 

						Enhance	ment factor	$(EF) = (I' - I_0)$	)/I <sub>0</sub> (%)				
	Chemical shift (cm <sup>-1</sup> ) /vibration mode		Spacin	g =1 cm			Spacing	g =2 cm			Spacin	g =3 cm	
	-	y-a	axis	z-a	axis	y-a	xis	z-a	xis	y-a	ixis	z-a	ixis
Naphthalene	1358 C-N stretching	244.2	202.0 1 67.6	93.2	112.0 1.000	164.1	1/0 2 1 21 1	72.8	540 - 15	75.2	000 1 0 1	42.0	
(NDA)	1594 N-H deformation vibration	339.8	292.0 ± 67.6	130.8	112.0 ± 26.6	134.3	149.2 ± 21.1	75.2	74.0 ± 1.7	86.7	80.9 ± 8.1	47.9	44.9 ± 4.2
	1450 CH <sub>2</sub> scissoring	245.6	252.51.11.4	108.9	121.0   10.2	144.4	127 ( ) 22 8	71.0	<b>7</b> 2 4 1 2 4	69.0	72 ( ) 5 1	46.4	50.21.5.2
P3	1615 Ring-skeletal stretch	261.7	253.7±11.4	134.7	121.8± 18.2	110.8	127.6 ± 23.8	75.7	/3.4 ± 3.4	76.2	/2.6± 5.1	54.0	50.2± 5.3
	1327 C-N stretching / CH <sub>2</sub> wagging	251.1		111.0		163.1		82.9		60.7		51.2	
PVP	1501 C-N stretching	278.4	272.6 ± 19.2	117.8	107.6 ±12.2	166.2	147.8± 29.3	91.4	82.3± 9.5	65.8	62.0± 3.3	53.4	58.4 ± 10.6
	1760 C=O stretching	288.2		94.1		114.0		72.5		59.6		70.6	

**Table S14** Enhancement factors of Raman signals (different vibration modes) of horizontal dimer nanojunctions composite with half the concentration of naphthalenediamine under different strengths of the external magnetic force.



Figure S8 Raman spectra of vertical dimer nanojunctions composite with half the concentration of benzimidazole under different strengths of the external magnetic force. The strength of the magnetic force applied on the composite can be tuned by changing the spacing between the composite and the magnetic source (magnetic bar). Raman spectra of nanocomposites with two different morphologies of dimer nanojunctions, vertical and horizontal dimer nanojunctions, are shown in (A) and (B), respectively.  $\Box$ 

						Enhanc	ement factor	(EF) = (I' -	$I_0)/I_0$ (%)				
	Chemical shift (cm <sup>-1</sup> ) /vibration mode		Spacing	g =1 cm			Spacing	g =2 cm			Spacing	g =3 cm	
	,	y-	axis		z-axis	y-a	axis		z-axis	y-a	ixis	z-a	ixis
Benzimidazole	1265 (C-H) in-plane bending	184.9	164 5 + 27 6	229.5	256 7 + 28 5	64.2	C0 4 ± 5 7	199.6	217.0 ± 25.9	17.2	105+25	158.0	154.0 ± 4.2
(BIM)	1595 N-H deformation vibration	145.9	104.5 ± 27.0	284.0	250.7± 58.5	72.6	08.4 ± 5.7	236.1	217.9 ± 25.8	22.7	19.5 ± 5.5	151.9	154.9 <u>+</u> 4.5
	1450 CH <sub>2</sub> scissoring	180.9	147.0 + 46.7	454.2		76.4	00.2   10.0	286.8	202.2 1 6 5	46.4	27.5   12.0	133.6	170 5 1 52 1
P3	1615 Ring-skeletal stretch	114.1	147.0 ± 46.7	391.5	422.8 <u>±</u> 44.4	104.3	90.3 ± 19.8	277.6	282.2 ± 0.5	29.0	37.5 ± 12.0	207.4	170.5 ± 52.1
	1327 C-N stretching / CH <sub>2</sub> wagging	118.9		568.0		84.9		175.4		16.6		236.3	
PVP	1501 C-N stretching	165.9	129.3 ± 31.6	485.7	414.6 ± 198.7	90.6	91.7 ± 7.5	311.2	198.7 ± 102.8	32.9	23.7 ± 8.0	236.3	144.4 ±79.8
	1760 C=O stretching	105.9		190.2		99.5		109.6		23.2		92.2	

**Table S15** Enhancement factors of Raman signals (different vibration modes) of vertical dimer nanojunctions composite with half the concentration of benzimidazole under different strengths of the external magnetic force.



Figure S9 Raman spectra of horizontal dimer nanojunctions composite with half the concentration of benzimidazole under different strengths of the external magnetic force. The strength of the magnetic force applied on the composite can be tuned by changing the spacing between the composite and the magnetic source (magnetic bar). Raman spectra of nanocomposites with two different morphologies of dimer nanojunctions, vertical and horizontal dimer nanojunctions, are shown in (A) and (B), respectively.  $\Box$ 

						Enhanc	ement factor	$(EF) = (I' - I_0)$	)/I <sub>0</sub> (%)				
	Chemical shift (cm <sup>-1</sup> ) /vibration mode		Spacing	g =1 cm			Spacing	g =2 cm			Spacing	g =3 cm	
	,	y-	axis		z-axis	y-a	axis	Z-á	axis	y-a	axis	z-a	ixis
Benzimidazole	1265 (C-H) in-plane bending	157.0	226.0 + 07.6	430.0	491.0 1 72.2	97.3		260.1	240.0 1 20.2	9.9	24.0 1 21 2	53.1	75 2 4 21 4
(BIM)	1595 N-H deformation vibration	295.1	220.0 ± 97.0	533.7	481.8 ± 73.3	191.1	144.2 ± 00.3	220.6	240.0 ± 28.3	39.9	24.9 ± 21.2	97.4	75.2 ± 51.4
DC.	1450 CH <sub>2</sub> scissoring	199.6	222.2 + 47.5	403.4	512.2 + 155.4	138.1	154.0 1 22.5	160.7	105.0 1 40.5	32.6	20.0 + 10.2	74.1	01.0 - 0.7
P3	1615 Ring-skeletal stretch	266.8	$233.2 \pm 47.5$	623.2	- 513.3 ± 155.4	170.0	154.0 ± 22.5	230.5	195.0 ± 49.5	47.2	39.9 ± 10.3	87.9	81.0± 9.7
	1327 C-N stretching / CH <sub>2</sub> wagging	224.5		462.9		131.0		1730.2		47.1		84.1	
PVP	1501 C-N stretching	306.5	293.7 ± 63.8	528.6	450.4 ± 85.1	171.8	153.7 ± 20.8	218.0	200.0 ± 23.8	31.1	53.1 ± 25.5	75.6	89.4 ± 17.0
	1760 C=O stretching	350.3		359.8		158.3		209.0		81.0		108.4	

**Table S16** Enhancement factors of Raman signals (different vibration modes) of horizontal dimer nanojunctions composite with half the concentration of benzimidazole under different strengths of the external magnetic force.



Figure S10 Raman spectra of vertical dimer nanojunctions composite with naphthalenediamine under different strengths of the external magnetic force. The strength of the magnetic force applied on the composite can be tuned by an external magnetic source (the number of magnetic bars). Raman spectra of nanocomposites with two different morphologies of dimer nanojunctions, vertical and horizontal dimer nanojunctions, are shown in (A) and (B), respectively. The corresponding Raman signal enhancement factors of different vibration modes are shown in (C).

**Table S17** Enhancement factors of Raman signals (different vibration modes) of vertical dimer nanojunctions composite with naphthalenediamine under different strengths of the external magnetic force (the number of magnetic bars).

				Enhan	cement factor	$(EF) = (I' - I_0)$	/I <sub>0</sub> (%)		
	Chemical shift (cm <sup>-1</sup> ) /vibration mode		Two mag	netic bars			One mag	netic bar	
	,	y-a	ixis	Z-a	axis	y-a	ixis	z-a	xis
Naphthalene	1358 C-N stretching	485.4	507 4 + 21 1	128.5	129 2   12 7	63.3	(05   40	7.7	11 0 1 5 0
(NDA)	1594 N-H deformation vibration	529.4	507.4 <u>+</u> 51.1	148.0	138.3 ± 13.7	57.7	00.5 ± 4.0	15.9	11.8 ± 5.8
DC	1450 CH <sub>2</sub> scissoring	528.8	591 2 1 74 2	226.3	205.0 1 20.1	45.7	(( A   <b>2</b> 0 A	56.3	22.2   24.0
P3	1615 Ring-skeletal stretch	633.7	581.5 ± 74.2	185.2	205.8 ± 29.1	87.8	00.8 ± 29.8	8.3	32.3 ± 34.0
	1327 C-N stretching / $CH_2$ wagging	505.6		204.9		24.2		23.3	
PVP	1501 C-N stretching	527.1	534.9 ± 33.8	204.9	270.6 ± 113.7	34.7	$44.2 \pm 26.1$	63.0	89.8 ± 83.3
	1760 C=O stretching	571.8		401.9		73.7		183.3	



Fig

**ure S11 Raman spectra of horizontal dimer nanojunctions composite with naphthalenediamine under different strengths of the external magnetic force.** The strength of the magnetic force applied on the composite can be tuned by an external magnetic source (the number of magnetic bars). Raman spectra of nanocomposites with two different morphologies of dimer nanojunctions, vertical and horizontal dimer nanojunctions, are shown in (A) and (B), respectively. The corresponding Raman signal enhancement factors of different vibration modes are shown in (C).

**Table S18** Enhancement factors of Raman signals (different vibration modes) of horizontal dimer nanojunctions composite with naphthalenediamine under different strengths of the external magnetic force (the number of magnetic bars).

				Enhan	cement factor	(EF) = $(I' - I_0)$	/I <sub>0</sub> (%)		
	Chemical shift (cm <sup>-1</sup> ) /vibration mode		Two mag	netic bars			One mag	netic bar	
	,	y-;	axis	Z-a	ixis	y-a	ixis	z-a	ixis
Naphthalene	1358 C-N stretching	723.4	600 2 1 52 6	168.1	1667 - 200	107.6	100 5   2.7	4.2183	24111
(NDA)	1594 N-H deformation vibration	649.0	088.2 <u>+</u> 52.0	165.2	100.7 ± 2.09	111.4	109.5 ± 2.7	2.621	3.4 <u>⊤</u> 1.1
DS	1450 CH <sub>2</sub> scissoring	654.8	744 7 ± 127 2	202.8	192 2 4 20 1	98.0	125 5 1 29 9	0.8518	80 ± 10 1
F3	1615 Ring-skeletal stretch	834.7	/44./ ± 12/.2	161.7	182.2 ± 29.1	152.9	125.5 <u>+</u> 58.8	15.17	8.0 ± 10.1
	1327 C-N stretching / $CH_2$ wagging	723.4		202.5		53.4		1.3195	
PVP	1501 C-N stretching	669.2	771.6 ± 133.2	222.1	205.2 $\pm$ 15.7	178.3	117.6 ± 62.5	4.4529	3.4± 1.8
	1760 C=O stretching	922.1		191.0		121.2		4.54	



**Figure S12 Raman spectra of vertical dimer nanojunctions composite with benzimidazole under different strengths of the external magnetic force.** The strength of the magnetic force applied on the composite can be tuned by an external magnetic source (the number of magnetic bars). Raman spectra of nanocomposites with two different morphologies of dimer nanojunctions, vertical and horizontal dimer nanojunctions, are shown in (A) and (B), respectively. The corresponding Raman signal enhancement factors of different vibration modes are shown in (C).

**Table S19** Enhancement factors of Raman signals (different vibration modes) of vertical dimer nanojunctions composite with benzimidazole under different strengths of the external magnetic force (the number of magnetic bars).

				Enhan	cement factor	$(EF) = (I' - I_0)$	/I <sub>0</sub> (%)		
	Chemical shift (cm <sup>-1</sup> ) /vibration mode		Two mag	netic bars			One mag	netic bar	
	•	y-a	axis	Z-a	axis	y-a	ixis	z-a	xis
Benzimidazole	1265 (C-H) in-plane bending	204.6	224 5 + 27 6	566.1	506 5 1 42 1	24.1	17.2 + 0.0	103	1095 ± 7.9
(BIM)	1595 N-H deformation vibration	244.0	224.5 ± 27.0	626.7	590.5 ± 43.1	10.6	17.5 ± 9.9	114	108.5 ± 7.8
DC	1450 CH <sub>2</sub> scissoring	187.3	170.0 + 11.2	543.6	509 5 + 7 1	12.2	11.2   1.4	46	91 5 1 50 3
P3	1615 Ring-skeletal stretch	171.8	179.0 ±11.3	652.8	598.5 ± 7.1	10.4	11.3 ± 1.4	117	81.5 ± 50.2
	1327 C-N stretching / CH <sub>2</sub> wagging	231.3		452.8		31.8		109	
PVP	1501 C-N stretching	166.1	<b>160.7±88.6</b>	760.8	$546.0 \pm 186.7$	24.2	23.3 ± 8.0	109	77.7 ± 54.3
	1760 C=O stretching	97.4		424.4		15.8		15	



Figure S13 Raman spectra of horizontal dimer nanojunctions composite with benzimidazole under different strengths of the external magnetic force. The strength of the magnetic force applied on the composite can be tuned by an external magnetic source (the number of magnetic bars). Raman spectra of nanocomposites with two different morphologies of dimer nanojunctions, vertical and horizontal dimer nanojunctions, are shown in (A) and (B), respectively. The corresponding Raman signal enhancement factors of different vibration modes are shown in (C).

**Table S20** Enhancement factors of Raman signals (different vibration modes) of horizontal dimer nanojunctions composite with benzimidazole under different strengths of the external magnetic force (the number of magnetic bars).

				Enhan	cement factor	$(EF) = (I' - I_0)$	/I <sub>0</sub> (%)		
	Chemical shift (cm <sup>-1</sup> ) /vibration mode		Two mag	netic bars			One mag	netic bar	
		у-	axis	z-a	ixis	у-а	ixis	z-a	xis
Benzimidazole	1265 (C-H) in-plane bending	747.1		881.4		38.3		214	
(BIM)	1595 N-H deformation vibration	621.0	684.0 ± 89.2	524.4	702.9 ± 252.4	24.6	31.4 ± 9.6	141	177.5 ± 51.6
DS	1450 CH <sub>2</sub> scissoring	638.9	$714.0 \pm 107.6$	861.7	750 8 ± 144 1	41.2	20.0 ± 15.9	163	1645 ± 2.1
<b>F3</b>	1615 Ring-skeletal stretch	791.0	/14.9 ± 107.0	657.9	759.0 <u>+</u> 144.1	18.8	50.0 <u>+</u> 15.8	166	104.5 <u>+</u> 2.1
	1327 C-N stretching / CH <sub>2</sub> wagging	577.0		758.5		29.7		156	
PVP	1501 C-N stretching	842.8	558.7 ± 293.7	1133.9	722.4 ± 430.7	62.8	30.8± 31.4	196	148.7 ± 51.4
	1760 C=O stretching	256.3		274.7		0.00		94	



Figure S14 Raman spectra of vertical dimer nanojunctions composite with half the concentration of naphthalenediamine under different strengths of the external magnetic force. The strength of the magnetic force applied on the composite can be tuned by an external magnetic source (the number of magnetic bars). Raman spectra of nanocomposites with two different morphologies of dimer nanojunctions, vertical and horizontal dimer nanojunctions, are shown in (A) and (B), respectively. The corresponding Raman signal enhancement factors of different vibration modes are shown in (C).

**Table S21** Enhancement factors of Raman signals (different vibration modes) of vertical dimer nanojunctions composite with half concentration of naphthalenediamine under different strengths of the external magnetic force (the number of magnetic bars).

				Enhan	cement factor	$(EF) = (I' - I_0)$	/I <sub>0</sub> (%)		
	Chemical shift (cm <sup>-1</sup> ) /vibration mode		Two mag	netic bars			One mag	netic bar	
		y-a	axis	z-a	ixis	y-a	ixis	z-a	xis
Naphthalene	1358 C-N stretching	289.6	260.1 + 28.0	138.4	110.9 + 26.2	44.4	47.5   4.4	33.3	27.2   0.4
(NDA)	1594 N-H deformation vibration	248.7	209.1 <u>+</u> 28.9	101.3	119.8 ± 20.3	50.7	47.5 ± 4.4	21.4	27.3 ± 8.4
DS	1450 CH <sub>2</sub> scissoring	267.3	266 0 ± 0 64	122.0	114.2 + 10.0	39.7	46.6 1 0 8	32.8	21.0 + 2.5
P3	1615 Ring-skeletal stretch	266.4	200. 9 ± 0.04	106.5	114.2 ± 10.9	53.6	40.0 ± 9.8	29.2	31.0 ± 2.5
	1327 C-N stretching / $CH_2$ wagging	268.0		120.9		42.4		23.5	
PVP	1501 C-N stretching	226.5	252.5 $\pm$ 22.7	84.7	99.6±18.9	33.6	38.4± 4.4	26.0	38.9 ± 24.5
	1760 C=O stretching	262.9		931.4		39.2		67.1	



Figure S15 Raman spectra of horizontal dimer nanojunctions composite with half the concentration of naphthalenediamine under different strengths of the external magnetic force. The strength of the magnetic force applied on the composite can be tuned by an external magnetic source (the number of magnetic bars). Raman spectra of nanocomposites with two different morphologies of dimer nanojunctions, vertical and horizontal dimer nanojunctions, are shown in (A) and (B), respectively. The corresponding Raman signal enhancement factors of different vibration modes are shown in (C).

**Table S22** Enhancement factors of Raman signals (different vibration modes) of horizontal dimer nanojunctions composite with half concentration of naphthalenediamine under different strengths of the external magnetic force (the number of magnetic bars).

				Enhan	cement factor	$(EF) = (I' - I_0)$	/I <sub>0</sub> (%)		
	Chemical shift (cm <sup>-1</sup> ) /vibration mode		Two mag	netic bars			One mag	netic bar	
	-	у-а	axis	z-a	ixis	y-a	ixis	z-a	xis
Naphthalene	1358 C-N stretching	244.2	202.0 + 67.6	93.2	112.0 + 26.6	21.2	17.0 1 6.0	36.0	20.0 1 5 5
(NDA)	1594 N-H deformation vibration	339.8	292.0 ± 07.0	130.8	112.0 ± 20.0	12.7	17.0 ± 0.0	43.8	39.9 ± 5.5
DC	1450 CH <sub>2</sub> scissoring	245.6	252 7 1 11 4	108.9	121 0 1 10 2	25.6	20.7 \ 5.7	26.7045	245 - 21
P3	1615 Ring-skeletal stretch	261.7	255./±11.4	134.7	121.8 <u>±</u> 18.2	33.6	29.7 ± 5.7	22.267	24.5 ± 3.1
	1327 C-N stretching / CH <sub>2</sub> wagging	251.1		111.0		18.7		46.5513	
PVP	1501 C-N stretching	278.4	272.6 ± 19.2	117.8	107.6 ±12.2	32.1	23.9 ± 7.2	42.6155	38.4 ± 10.9
	1760 C=O stretching	288.2		94.1		20.9		26.0061	



Figure S16 Raman spectra of vertical dimer nanojunctions composite with half the concentration of benzimidazole under different strengths of the external magnetic force. The strength of the magnetic force applied on the composite can be tuned by an external magnetic source (the number of magnetic bars). Raman spectra of nanocomposites with two different morphologies of dimer nanojunctions, vertical and horizontal dimer nanojunctions, are shown in (A) and (B), respectively. The corresponding Raman signal enhancement factors of different vibration modes are shown in (C).

**Table S23** Enhancement factors of Raman signals (different vibration modes) of vertical dimer nanojunctions composite with half concentration of benzimidazole under different strengths of the external magnetic force (the number of magnetic bars).

				Enhan	cement factor	$(EF) = (I' - I_0)$	/I <sub>0</sub> (%)		
	Chemical shift (cm <sup>-1</sup> ) /vibration mode		Two mag	netic bars			One mag	netic bar	
	•	y-a	axis	Z-á	axis	y-a	ixis	z-a	ixis
Benzimidazole	1265 (C-H) in-plane bending	184.9	1645 1 27 6	229.5	256 7 1 29 5	4.3	01   71	46.5	12 5 1 4 4
(BIM)	1595 N-H deformation vibration	145.9	104.5 ± 27.0	284.0	250.7± 38.5	14.0	9.1 ± 7.1	40.4	43.5 <u>+</u> 4.4
DC	1450 CH <sub>2</sub> scissoring	180.9	147.0 + 46.7	454.2	422.01.44.4	9.6	05107	23.2	() ( ) 55 (
25	1615 Ring-skeletal stretch	114.1	147.0 ± 40.7	391.5	422.8± 44.4	10.1	9.5 ± 0.7	101.9	62.6 ± 55.6
	1327 C-N stretching / CH <sub>2</sub> wagging	118.9		568.0		18.4		15.5	
PVP	1501 C-N stretching	165.9	<b>129.3 ± 31.6</b>	485.7	$414.6 \pm 198.7$	16.0	22.7 ± 9.9	51.6	23.7± 24.9
	1760 C=O stretching	105.9		190.2		34.7		4.0	



Figure S17 Raman spectra of horizontal dimer nanojunctions composite with half the concentration of benzimidazole under different strengths of the external magnetic force. The strength of the magnetic force applied on the composite can be tuned by an external magnetic source (the number of magnetic bars). Raman spectra of nanocomposites with two different morphologies of dimer nanojunctions, vertical and horizontal dimer nanojunctions, are shown in (A) and (B), respectively. The corresponding Raman signal enhancement factors of different vibration modes are shown in (C).

**Table S24** Enhancement factors of Raman signals (different vibration modes) of horizontal dimer nanojunctions composite with half concentration of benzimidazole under different strengths of the external magnetic force (the number of magnetic bars).

				Enhan	cement factor	(EF) = $(I' - I_0)$	/I <sub>0</sub> (%)		
	Chemical shift (cm <sup>-1</sup> ) /vibration mode		Two mag	netic bars			One mag	netic bar	
		y-;	axis	Z-a	axis	y-a	ixis	z-a	xis
Benzimidazole	1265 (C-H) in-plane bending	157.0		430.0		8.9		0.6	
(BIM)	1595 N-H deformation vibration	295.1	226.0 ± 97.6	533.7	481.8 ± 73.3	36.8	22.8 ± 19.7	89.4	45.0 ± 62.8
DS	1450 CH <sub>2</sub> scissoring	199.6	222.2 ± 47.5	403.4	512 2 ± 155 4	0.3	187+260	34.0	71 5 + 52 0
F3	1615 Ring-skeletal stretch	266.8	233.2 ± 47.5	623.2	515.5 <u>+</u> 155.4	37.2	18.7± 20.0	108.9	/1.5 <u>+</u> 55.0
	1327 C-N stretching / CH <sub>2</sub> wagging	224.5		462.9		4.5		19.0	
PVP	1501 C-N stretching	306.5	$\boxed{293.7\pm63.8}$	528.6	450.4 ± 85.1	2.7	7.3 ± 6.4	52.2	70.1 ± 62.0
	1760 C=O stretching	350.3		359.8		14.5		139.1	



**Figure S18 Raman response of dimer-nanojunction composites with 2-Mercapto-5-nitrobenzimidazole** (MNB) under external magnetic field (MF). (A) Extinction spectra of two dimer-nanojunction composites: vertical dimer (blue curve) and horizontal (red curve). The corresponding SEM images are in the right panel. (B) and (C) show the Raman spectra of vertical and horizontal dimer-nanojunction composites under three different conditions, respectively. the three different conditions are no external MF (black curve), under external MF parallel to the substrate (y-axis red curve), and under external MF perpendicular to the substrate (z-axis red curve). (D) The corresponding chemical vibration modes of MNB, PVP (ligand for AgNC), and PS (matrix) were listed.

Table S25 Enhancement factors of Raman signals (different vibration modes) of vertical dimer

nanojunctions composite with different magnetic materials.

	Enhancement factor (EF) = $(1'-I_0)/I_0$ (%)											
	BIM (van der Waals)					NDA (hydrog	gen bonding)		MNB (covalent bonding)			
	y-axis		z-axis		y-axis		z-axis		y-axis		z-axis	
Magnetic material	204.6	- 224.5 ± 27.6	566.1	- 596.5 ± 43.1	485.4	- 507.4 ± 31.1 ·	128.5	- 138.3 ± 13.7	95.9	- 88.9 ± 7.4	192.1	189.0 ± 22.1
									81.2		165.9	
	244.0		626.7		529.4		148.0		89.6		209.9	
PS	187.3	- 179.0 ±11.3	543.6	- 598.5 ± 7.1	528.8	- 581.3 ± 74.2	226.3	- 205.8 ± 29.1	88.7	- 97.6± 12.6	176.0	- 207.3 ± 44.3
	171.8		652.8		633.7		185.2		106.5		238.6	
PVP	231.3	160.7±88.6	452.8	546.0 ± 186.7	505.6	534.9 ± 33.8	204.9	270.6 ± 113.7	96.3	87.0 ± 26.6	174.8	175.2 ± 30.6
	166.1		760.8		527.1		204.9		107.6		206.0	
	97.4		424.4		571.8		401.9		57.0		144.8	

Table S26 Enhancement factors of Raman signals (different vibration modes) of horizontal dimer nanojunctions composite with different magnetic materials.

	Enhancement factor (EF) = $(I'-I_0)/I_0$ (%)											
	BIM (van der Waals)				NDA (hydrogen bonding)				MNB (covalent bonding)			
	y-axis		z-axis		y-axis		z-axis		y-axis		z-axis	
Magnetic material	747.1	- 684.0 ± 89.2	881.4		723.4	- 688.2 ± 52.6 ·	168.1	- 166.7 ± 2.09	91.3	91.2 ± 0.9	200.2	- 231.0 ± 45.9
									92.0		212.0	
	621.0		524.4		649.0		165.2		90.3		280.7	
PS	638.9	-714.9 ± 107.6	861.7	- 759.8 ± 144.1	654.8	-744.7 ± 127.2	202.8	· 182.2 ± 29.1	97.2	89.9 ± 10.3	186.8	- 219.0 ± 68.1
	791.0		657.9		834.7		161.7		82.6		251.7	
PVP	577.0	558.7 ± 293.7	758.5	722.4 ± 430.7	723.4	771.6 ± 133.2	202.5	205.2 ± 15.7	106.0	102.3 ± 12.5	226.8	283.4 ± 43.5
	842.8		1133.9		669.2		222.1		88.3		264.4	
	256.3		274.7		922.1		191.0		112.5		359.0	



## (B) Nanocomposite with BIM



**Figure S19 The reproducibility test of nanocomposites with magnetic materials for magnetic sensing application.** Through the change of Raman scattering spectrum changes with the change of external MF, it can be observed that after the external MF is removed, the rearrange of molecules around the dimer nanojunction returns to the original state. This allows these nanocomposites to be reused.