Electronic Supplementary Material (ESI) for Green Chemistry.

Electronic Supplementary Information

Mobilization of platinum and palladium from exhausted catalytic converters using bio-cyanide and ionic-liquid as mass transport carriers†

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Table S1. Literature summary of PGMs' extraction using ionic liquids at different conditions and salient features.

Ionic liquid	Optimal Concentration	Important remarks	References
Polymerized supported IL	IL 20% yielded 86% Pt and 96% Pd recovery of purity 99%.	PSILP material demonstrated excellent separation of PGMs from major accompanying interferences in a single separation step.	[1]
Aliquat-336	3 mg/L Aliquat-336 yielded >99% extraction efficiency of PGMs, selective stripping of Pd in 1.0 mol.L^{-1} NaOH and Pt in 1.0 mol.L^{-1} thiourea was achieved.	The authors obtained a good selectivity over Au(III) over Pt and Pd in the extraction stage.	[2]
$[Tf_2N]^-$ IL	100% as such solvent used disulfide, alkenyl, and nitrile group attached ionic liquid exhibited high Pd-extraction.	Cation ring structure showed a large influence on the extraction process.	[3]
Cyphos IL 104	Without dilution used IL yielded selective Ru(III) with 70% efficacy, leaving all Rh(III) into raffinate.	Stripping was performed using 0.1 mol.L^{-1} thiourea in 0.5 mol.L^{-1} HCl.	[4, 5]
Cyphos IL 101	0.6 g/L IL 101 used that yielded >99% Pt-Pd extraction over Rh. Co-extracted Pt and Pd was separated by sequential stripping with NaSCN and CH_4N_2S.	Stoichiometry requirement of ionic liquid changes from 1 to 3 times with differing acid concentration from 0.1−4.0 mol.L^{-1}; however, Pt did not show any effect of acid concentration.	[5, 6]

Table S2. Summary of the test procedures adopted for toxicity assessment.

Item description	**TCLP**	**SPLP**	**TTLC**
Leaching agents	$C_2H_4O_2$, H_2O	H_2SO_4, H_2O	HNO_3, HCl, H_2O_2, H_2O
Sample amount	100 g	100 g	1.0 g
Volume	2 L	2 L	100 mL
Duration	18 h	18 h	48 h
Analyte	Heavy metals	Heavy metals	Heavy metals
Instrument used	ICP-MS	ICP-MS	ICP-MS

Table S3. The conditions used for determining the energy consumption for milling of exhausted catalytic converters to size reduction up to 150 μm.

Milling type	Equation applied for power consumption	Conditions
Gyratory milling	$\{W_i \times Q [\sqrt{f80} - \sqrt{P80}] \times \sqrt{(100/P80)}\}/\sqrt{f80}$ (in kW) where	Where, Wi is work index = 15 $kWh.t^{-1}$; Q is capacity = 1 $t.h^{-1}$; f_{80} is the size through which 80% of the mineral feed passes = 50 mm; P_{80} is the size through which 80% of the product passes = 5 mm
Ball milling	$W = W_i \times ((10/\sqrt{P}) - 10/\sqrt{F}))$	Where, W is the energy consumption for grinding (in $kWh.t^{-1}$); Wi is work index (in $kWh.t^{-1}$); P is the screen aperture through which 80% of the material passes before grinding (in μm); F is the screen aperture size through which 80% of the material passes before grinding (in μm)
	$W_i = 1.1 \times 44.5/(Pk^{0.23}G^{0.82}((10/\sqrt{P}) - 10/\sqrt{F}))$	Where, Wi is work index (in $kWh.t^{-1}$); P is the screen aperture through which 80% of the material passes before grinding (in μm); F is the screen aperture size through which 80% of the material passes before grinding (in μm); P_k is the aperture size of test screen used for determination of the work index (in μm); G is the newly formed mass passing a test screen each mill revolution (in g).

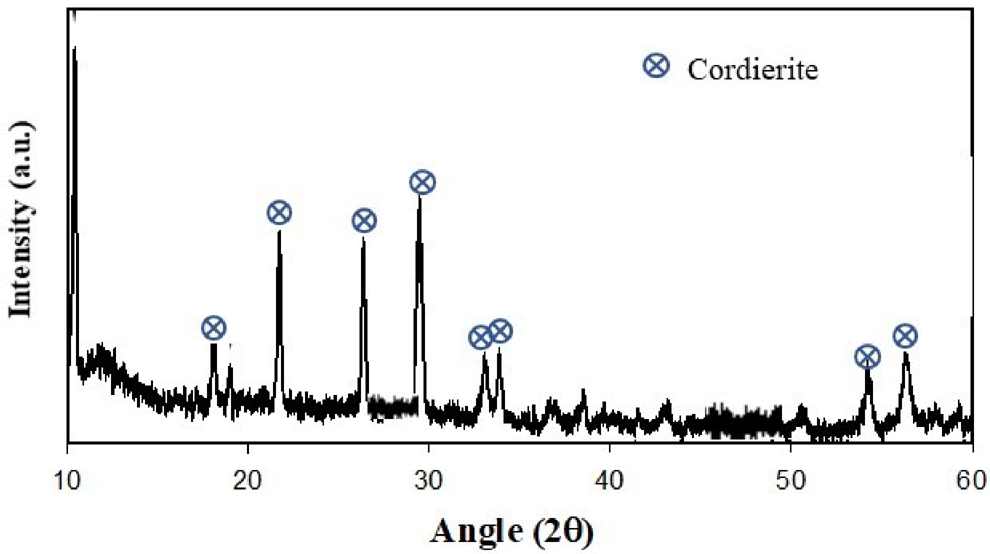

Fig. S1. XRD pattern of exhausted catalytic converters.

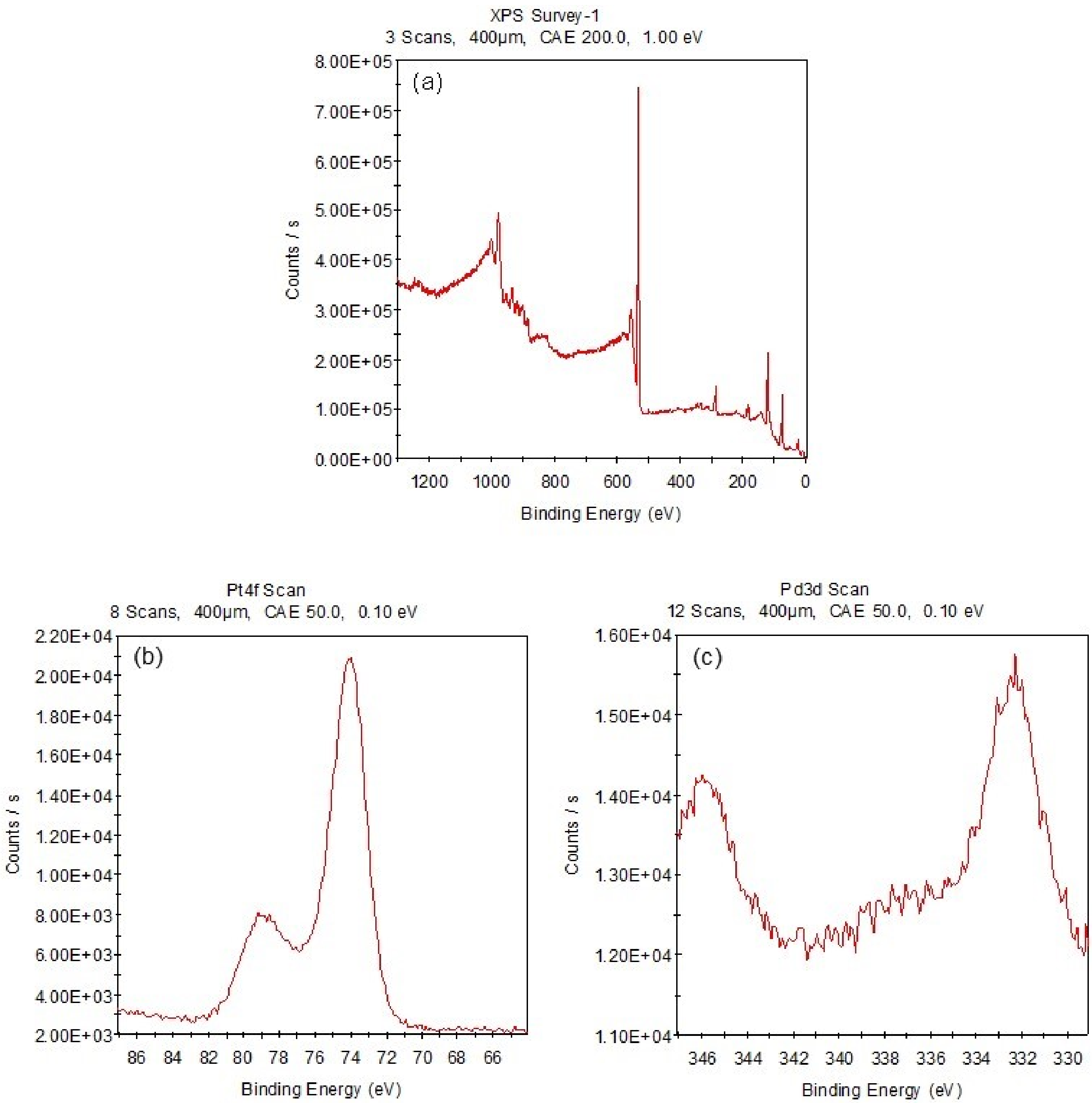

Fig. S2. XPS analysis of the sample for full scan **(a)**, Pt **(b)**, and Pd **(c)** scan.

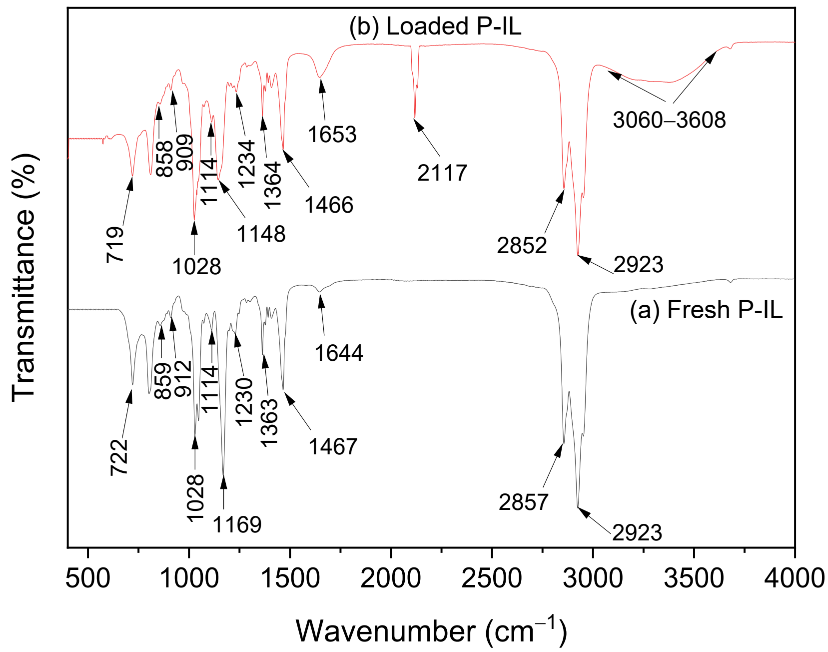

Fig. S3. FTIR spectrum of fresh ionic-liquid Cyphos IL101 **(a)** and (Pt,Pd)-loaded ionic-liquid phase **(b)**.

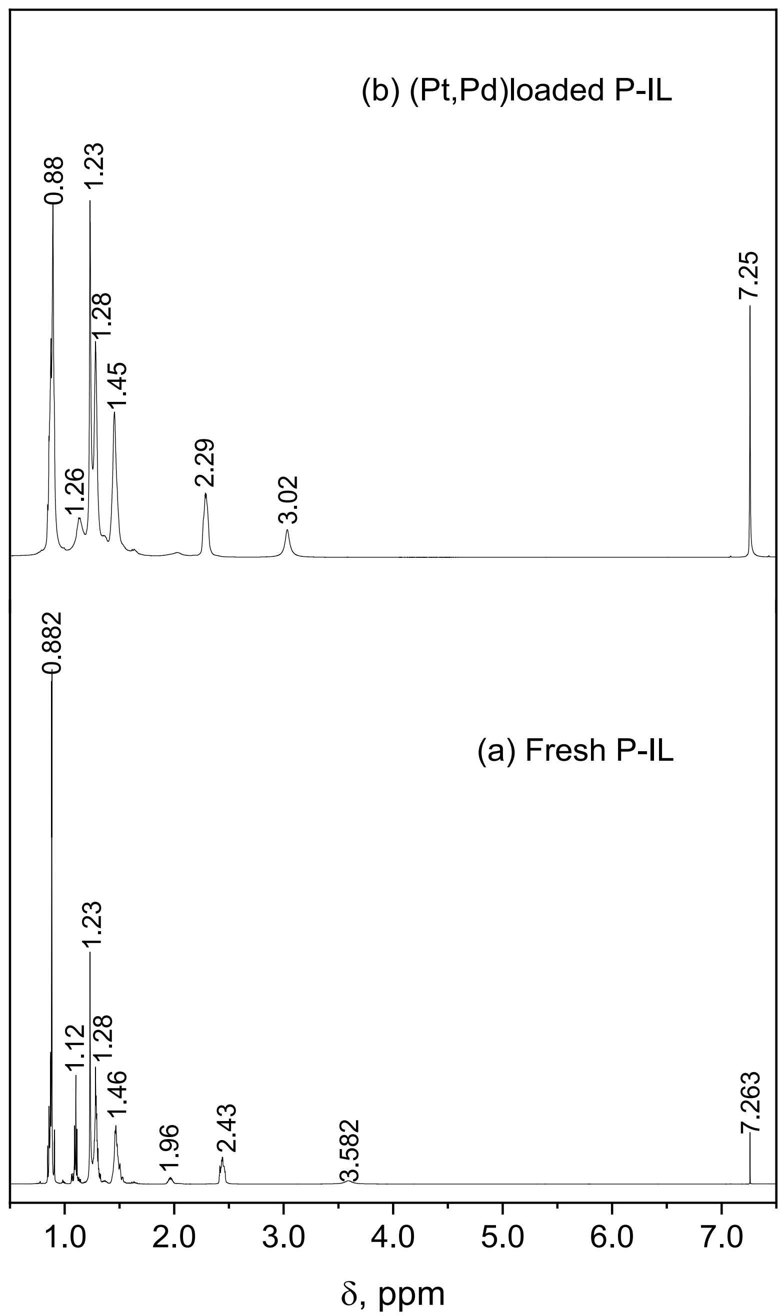

Fig. S4. ^{1}H-NMR of fresh **(a)** and (Pt,Pd)-loaded **(b)** ionic liquid phase.

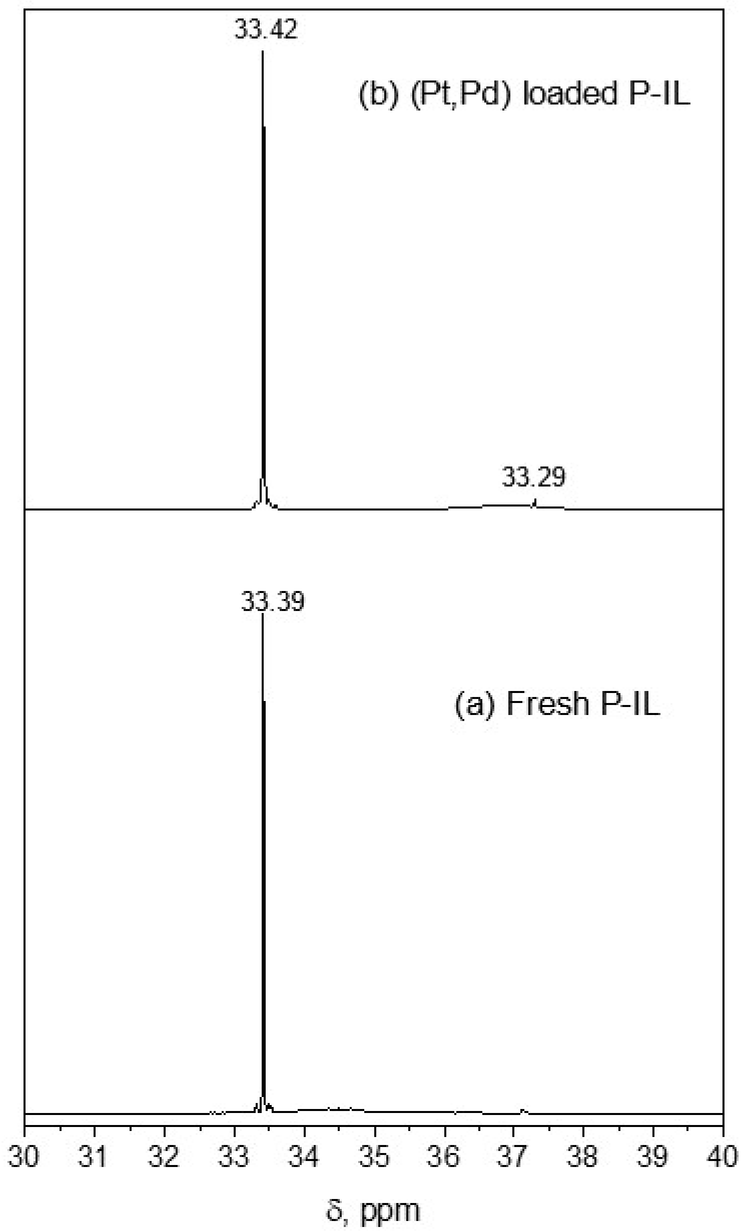

Fig. S5. ^{31}P NMR of fresh **(a)** and (Pt,Pd)-loaded **(b)** ionic liquid phase.

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