Decree of the Rector n. 1005 of 12/10/2023
Competition for awarding 1 research grant at the University of Udine

DISCLAIMER:
The official and legally binding call for applications is in Italian only.
This document cannot be used for legal purposes and is only meant to provide information in English on the call for applications (Decree of the Rector n. 1005 of 12/10/2023). Please refer to the official call published on: https://www.uniud.it/it/albo-ufficiale

Any change and integration will be made available on the above mentioned web page. Therefore, no personal written communication regarding the examination date and/or competition results shall be provided to applicants.

Annex 1

Competition announcement for the assignment of 1 research grant at the University of Udine, entitled “Selective formation of critical metal complexes for their recovery from e-waste” SSD: CHIM/07 (principal investigator, Marilena Tolazzi)

Research grant co-funded by the resources of the project PRIN 2022 - Prot. n. 2022HYH95P

Art. 1
A selection procedure is hereby launched for the award of 1 research grant at the University of Udine, as identified in Attachment A which constitutes an integral part of the present announcement.
The research grant is linked to the research project and is subject and conditioned upon the relative funding.
The fellowship may be renewed, in compliance with Art. 22, Law No. 240 of 30 December 2010 (as in the text in force before the implementation of the Conversion Law of the D.L. 36/2022, L. 79/2022), Law No. 11 of 27 February 2015, and the current regulations of the University of Udine for awarding research grants, issued with the Rector’s Decree No. 182 of 31 March 2021. The renewal is subject to the scientific coordinator’s positive assessment of the researcher’s activities, an adequate scientific rationale, and a corresponding financial covering.
The research fellowship does not give rise to any right with regards to accessing University posts.

Any personal communication to candidates related to this selection will be sent exclusively to the email address indicated when registering for the selection, as mentioned in Art. 5.

Art. 2
The research grant described in this competition announcement and the required qualifications to apply for the position are identified in Attachment A. The lack of the admission requirements leads to the automatic exclusion from the competition procedure.

Possession of a PhD or equivalent degree obtained abroad or, only for the interested areas, of a medical specialization accompanied by an adequate scientific production, constitutes a preferential qualification for awarding the research fellowship of this selection, if it has not been provided as a mandatory requirement.
For the only purpose of the admission to the competition, the Examining Board (Art. 7) shall assess the equivalence of the qualification obtained abroad, except for the evaluation of the medical specialization qualification to which Article 38 of the Legislative Decree 165/2001 and subsequent modifications and additions, and EU regulations on the matter, shall be applied.

The Examining Board will proceed to the evaluation of the qualification obtained abroad according to the documentation attached to the application form. The Examining Board may exclude the candidate if the submitted documentation does not provide sufficient information for the assessment. Therefore, applicants must enclose all the documentation in their possession relating to their qualification in order to provide the Examining Board with sufficient information for assessment.

Candidates holding a qualification issued by a European Research Area country, if successful, must submit, if not already attached to the application form one of the following options:
- Supplement Diploma in English issued by the competent University.
- CIMEA Certificate of comparability of the foreign qualification, issued by CIMEA (Information Centre on Academic Mobility and Equivalence) via the "diplome" service at https://cimea.diplo-me.eu/udine/#!/auth/login

Candidates holding a qualification issued by a non-European Research Area country, if successful, must submit, if not already attached to the application form one of the following options:
- Declaration of the on-site value of the qualification and the certificate relating to the degree with examinations and grades. A certificate in a language other than Italian or English must be accompanied by an official translation into one of these languages (certified by the competent diplomatic-consular authority or certified by a court in Italy).
- CIMEA Certificate of comparability of the foreign qualification, issued by CIMEA (Information Centre on Academic Mobility and Equivalence) via the "diplome" service at https://cimea.diplo-me.eu/udine/#!/auth/login

If the Supplement Diploma or the statement/attestation of comparability are not available when signing the contract, the applicant must demonstrate that he/she has requested the documentation and submit it as soon as possible.

Any exclusion from the selection procedure due to lack of eligibility requirements, absence of required documents, failure to sign the selection application or submission of the selection application in a manner different from what is provided for in this call for applications will be communicated to applicants exclusively at the email address indicated in the application form.

Art. 3

The research grant referred to in this call for applications cannot be awarded:

a. to employees of Universities and the entities referred to in Article 22, section 1, of Italian Law no. 240 of 30 December 2010 (in the text prior to the reform introduced by Law no. 79 of 29 June 2022);

b. to those who have already been awarded research grants pursuant to Italian Law no. 240 of 30 December 2010 (prior to the reform introduced by Law no. 79 of 29 June 2022) for the maximum period provided by law, even if not continuously, excluding the period in which the grant was used in conjunction with the doctorate, up to the legal term of the relative course;

c. to those who have already benefited from research grants and fixed-term researcher contracts provided for, respectively, in Articles 22 and 24 of Italian Law no. 240 of 30 December 2010 (in the
text prior to the reform introduced by Law no. 79 of 29 June 2022), for a total of 12 years, even if not consecutive;
d. to anyone who has a degree of kinship or affinity, up to and including the fourth degree, with:
- the Rector, the Director General or a member of the Board of Directors of the University of Udine;
- the scientific supervisor or a professor/researcher belonging to the department or organisation hosting the research grant in question.

The research grant provided for in this call for applications cannot be combined:
a) with scholarships of any kind, except for those granted by Italian or foreign institutions to supplement, by means of stays abroad, the fellow's training or research activities;
b) with other research grants;
c) with an employment relationship, even if part-time, without prejudice to the relevant provisions for employees of public administrations.

The grant awarded under this call for applications is also incompatible with simultaneous attendance at university degree courses, either Bachelor's degree or Master’s degree courses, research Doctorates with scholarships and medical specializations, in Italy or abroad.

Art. 4
Applicants must enclose with their application, under penalty of exclusion, the following documents:
a) their professional scientific CV, highlighting the candidate's aptitude for carrying out and implementing the research project (Attachment A);
b) their identity card, their passport or any other identification document¹;
c) (for candidates with a foreign qualification only) certification or self-certification of both the academic qualification required for the admission to the selection, and of the exams (with evaluation) taken during the period of study abroad, and of any other document that can be useful to the evaluation of the degree by the Examining Board.

Applicants can attach to the application, publications and any other certification considered useful to demonstrate the qualification based on the research program (Attachment A) and to certify any research activity accomplished at public or private institutes (indicating the starting and ending date and the duration).

The documents and qualifications mentioned above must be submitted in Italian or English. Those that are not as requested will not be evaluated. Documents originally written in a language other than Italian or English must come with a translation in Italian or English, that the candidate will do on its own responsibility. The translation can be an abstract concerning the thesis.

Italian and Community candidates wishing to submit qualifications referring to conditions and facts attested by Public Administrations must proceed exclusively with self-certification. Non-EU citizens legally residing in Italy may self-certify only data that can be verified or certified by Italian public bodies. They may also use declarations in lieu when provided for by an international convention between Italy and the declarant's country of origin. Non-EU citizens not residing in Italy cannot self-certify.

Only the qualifications possessed by the candidate on the date the application form is submitted and submitted in accordance with the procedures set out in Article 5 will be assessed.

¹ Please be aware that the residence permit is not an identification document.
Failure to submit mandatory documents provided for in this article will constitute grounds for exclusion from the selection.

Art. 5
The submission of the applications for the present call starts on October 19, 2023 at 2:00 pm (Italian time) and ends on November 10, 2023 at 2:00 pm (Italian time).

The application to take part in the selection must be completed, under penalty of exclusion, using the appropriate online procedure, available at the link https://pica.cineca.it/

The procedure involves an applicant registration step, for those who do not already have an account, and then an application completion step.

Once completed, the online application must be signed in the manner described in the online procedure (manual signature with attached identity document or digital signature), under penalty of exclusion from selection. The application does not have to be signed if you access the above-mentioned online procedure using your SPID ID.

The qualifications referred to in Article 4 must be attached to the application in .pdf format. Individual .pdf files may not exceed 30MB.

The application for participation in the selection is automatically sent to the University of Udine with the definitive closing of the online procedure.

The University Administration:
- is not responsible if it is impossible to read the submitted documentation in electronic format due to damaged files;
- shall not accept or take into consideration qualifications or documents received in paper form or by any means other than what is specified in this article.

Reference to documents or publications already submitted in connection with other competitions is not allowed.

The Administration is not responsible for any missing document or communication because of inaccurate indication of residence and/or address submitted by the candidate during the application. Also, the Administration is not responsible if the candidate has not communicated changes in this information, or has communicated them too late. The Administration is also not responsible for any postal or telegraphic problems not attributable to the Administration itself.

Applicants are advised not to wait until the last few days before the closing date to submit their application. The University accepts no responsibility for any malfunctions due to technical problems and/or overloading of the communication line and/or application systems.

Art. 6
The selection procedure is held in accordance with the modality indicated in Attachment A.

The test will aim to assess the general preparation, experience and aptitude for research of the candidate. It will consist in the evaluation of the professional scientific curriculum, of the publications and qualifications presented, and of the interview, where foreseen.
Art. 7
The Examining board for the competition is identified in Attachment A of the present competition announcement, of which it is an integral part.

At its first meeting, the Examining board shall appoint its President and Secretary, and establish the criteria and methods for evaluating the qualifications and the interview, where foreseen.

The results of the qualifications assessment must be disclosed to applicants during the interview, where foreseen.

The Examining board can award a maximum of 100 points (one hundred out of one hundred) to the selection.

At the end of the evaluation procedure, the Examining board shall formulate the general merit list based on the overall score of each candidate, and draw up the minutes of the whole competition procedure.

Based on the ranking list, the assignment is awarded to candidates who have obtained a minimum overall score of 70/100 (seventy out of one hundred).

The Examining board's judgement is final.

The ranking list will be made public exclusively through publication on the University's official website.

Applicants will not be notified of the outcome of the evaluation.

Those who do not declare their acceptance of the research grant and do not present themselves at the research centre within the deadline communicated by the latter, even if not formally, shall lose the right to receive it. Exceptions to this term will only be granted in cases of documented force majeure.

Art. 8
The research activity cannot be started before signing the contract defining the terms and conditions of the collaboration.

The activity covered by the research grant must have the following characteristics:

a) it must be carried out as part of the research programme covered by the grant and not be a merely technical support to it;

b) it must have a close connection with the realization of the research program for which the winner of the grant has been awarded the contract;

c) it must be continuous and, in any case, temporally defined, not merely occasional, and in coordination with the overall activity of the University;

d) it must be carried out autonomously, solely within the limits of the programme prepared by the programme supervisor, without predetermined working hours.

The researcher is required to submit a detailed written report on the work carried out and the results achieved, accompanied by the opinion of the scientific supervisor, to the reference organisation at the intervals set out in the contract. The researcher must also submit interim reports and timesheets, if requested by the reference organisation.

Either the fellow or the reference organisation may withdraw from the contract.

RESEARCH SERVICES AREA
Research Training Office
Department Head: Sandra Salvador
Procedure Supervisor: Sandra Salvador
Procedure Compiler: Francesca Milon
The reference organisation may terminate the contract not only in the cases referred to in Article 9, sections 2 and 3, of the "Internal rules for awarding research grants pursuant to law 240 of 30 December 2010" of the University of Udine, but also in the event the research project and therefore the financial coverage on which the research grant is based cease to exist.

**Art. 9**

The following legal dispositions shall apply to the grant referred to in this call for applications:
- for tax matters, the provisions of Article 4 of Italian Law no. 476 of 13 August 1984, as subsequently amended and supplemented;
- for social security matters, the provisions of Article 2(26) et seq. of Italian Law no. 335 of 8 August 1995, as subsequently amended and supplemented;
- for mandatory maternity leave, the provisions of the Italian Ministerial Decree of 12 July 2007;
- with regard to sick leave, the provisions of Article 1(788) of Italian Law no. 296 of 27 December 2006 and subsequent amendments.

During the period of mandatory maternity leave, the allowance paid by INPS according to Art. 5 of the Italian Ministerial Decree of 12 July 2007 is supplemented by the University up to the full amount of the research grant.

The grant will be paid in monthly instalments.

**Art. 10**

The data collected as part of the procedure referred to in Art. 5 are necessary to properly manage the selection procedure, for any subsequent management of the research grant and for purposes related to managing services provided by the University. The University of Udine is the Data Controller. At any time, the data subject may request access, rectification and, depending on the University's institutional purposes, cancellation and restriction of processing or oppose the processing of their data. The data subject can always lodge a complaint with the Italian Data Protection Authority. The complete disclosure is available on the University of Udine website in the "Privacy" section, accessible from the home page [www.uniud.it](http://www.uniud.it) Direct Link: [https://www.uniud.it/it/pagine-speciali/guida/privacy](https://www.uniud.it/it/pagine-speciali/guida/privacy)

**Art. 11**

For all matters not expressly mentioned in this call for applications, refer to the regulations in force on the subject cited in the introduction and to the "Internal rules for awarding research grants pursuant to Italian Law no. 240 of 30 December 2010" of the University of Udine, issued by Rector's Decree no. 182 of 31 March 2021.

**Art. 12**

The procedure supervisor is Dr Sandra Salvador, Head of the Research Services Area of the University of Udine.

The Responsible office at the University of Udine is “Area Servizi per la Ricerca - Ufficio Formazione per la Ricerca”, via Mantica n. 31 - 33100 Udine, Italia.

To request information about the call for applications, please complete the following form available on the University of Udine website:
[https://helpdesk.uniud.it/SubmitSR.jsp?type=req&accountId=universityofudine&populateSR_id=42105](https://helpdesk.uniud.it/SubmitSR.jsp?type=req&accountId=universityofudine&populateSR_id=42105)
Attachment A

Responsabile scientifico della ricerca / Principal investigator:
Nome e cognome / Name and surname: Marilena Tolazzi
Qualifica / Position: Professore Ordinario / Full Professor
Dipartimento / Department: Politecnico di Ingegneria e Architettura (DPIA) / Polytechnic of Engineering and Architecture
Area MUR / Research field: 03 – Scienze Chimiche
Settore concorsuale e Settore scientifico disciplinare / Scientific sector: 03/B2; CHIM/07 – Fondamenti chimici delle tecnologie

Titolo dell’assegno di ricerca / Topic of the research fellowship “assegno di ricerca”:
I bandi sono consultabili dal sito dell’Ateneo, del MUR e di Euraxess / The calls are available on the University, MUR and Euraxess websites

Testo in italiano:
Formazione selettiva di complessi di metalli critici per il loro recupero da e-waste.

Testo in English:
Selective formation of critical metal complexes for their recovery from e-waste.

Obiettivi previsti e risultati attesi del programma di ricerca in cui si colloca l’attività dell’assegno di ricerca / Foreseen objectives and results of the research programme performed by the research fellow “assegno di ricerca”:
I bandi sono consultabili dal sito dell’Ateneo, del MUR e di Euraxess / The calls are available on the University, MUR and Euraxess websites

Testo in italiano:

Abstract del progetto
Il progetto si occupa della progettazione e dello sviluppo di nuovi nanomateriali, basati su materiale riciclati da biomasse di scarto, in grado di rilevare, legare ed estrarre materie prime critiche (CRM) come Nd, Dy e Pd da soluzioni che simulano rifiuti elettronici. Una volta assorbiti, i solventi verdi come Deep Eutectic Solvents (DES) saranno testati per il desorbimento come alternativa al classico trattamento. A questo scopo verranno utilizzati modelli termodinamici e cinetici per definire il meccanismo di assorbimento, l’equilibrio e la velocità costanti e l’entalpia di assorbimento. Metodi computazionali saranno utilizzati per supportare l’interpretazione dei dati sperimentali e guidare la messa a punto dei materiali assorbenti. Il progetto consentirà di collegare gli scarti provenienti dai cicli di produzione alimentare con quelli della filiera digitale, creando un nuovo (bi)ciclo ad un livello ancora più elevato. Il progetto mira a un miglioramento sociale ed economico visto che dovrà affrontare temi come la gestione dei rifiuti, economia circolare e recupero dei CRM.

Obiettivi del progetto
Lo scopo di questo progetto è valutare la fattibilità dell’utilizzo di nuovi materiali multifunzionali basati sui materiali riciclati da biomasse per il recupero dei CRM da soluzioni simulate di rifiuti elettronici. Il progetto ha due obiettivi principali: a) valorizzazione della biomassa di scarto; b) sviluppo di nuovi protocolli sostenibili da recuperare CRM. Per raggiungere questo obiettivo, è essenziale determinare la cinetica e
termodinamica dei complessi nei processi di estrazione e separazione. Ciò sarà ottenuto attraverso una combinazione di metodi sperimentali e computazionali. Successivamente, si procederà con il recupero degli CRM adsorbiti su biomateriali grazie ai DES.

| Stato dell'arte | Secondo i dati ISMEA 2021, in Italia la quantità di rifiuti provenienti dalla filiera agroalimentare di olive, agrumi, uva e frutta a guscio è di circa 4000 kt/a. Nuovi approcci per gestire le biomasse di scarto sono temi caldi per la ricerca applicata e i programmi governativi, come mostra, ad esempio, in Italia il "PNRR, Mission 2C1, Economia circolare e agricoltura sostenibile". Parallelamente, l'UE ha istituito diverse CRM in quanto avranno un'importanza crescente per diversi settori strategici (es. e-mobility, difesa, generazione elettrica, elettronica) nei prossimi anni e la loro fornitura è associata alto rischio [1]. Tra questi, gli elementi delle terre rare (REE) e i metalli del gruppo del platino (PGM) sono tra i più cruciali. Informazione e l'industria tecnologica della comunicazione (ICT), ad esempio, richiede materie prime scarsamente disponibili in natura o localizzate politicamente aree instabili [2]. L'UE dipende in gran parte da altri paesi per i componenti e gli assemblaggi ad alta tecnologia; Inoltre, il recupero di CRM dalle tecnologie ICT è attualmente influenzato dal loro limitato potenziale di riciclaggio, a causa di cattivi progetti industriali e scarsa selettività di separazione verso miscele di elementi [3,4]. In questo contesto, il duplice obiettivo di ridurre la quantità di rifiuti e sviluppare nuovi protocolli di riciclaggio sostenibili ed efficienti è obbligatorio attenuare l'effetto della crisi dovuta alla scarsità di CRM, problemi geopolitici e consumo di nuove risorse. I processi finalizzati al recupero di composti ad alto valore sono un'occasione d'oro per valorizzare i rifiuti come miniere urbane [5]. D'altra parte, se non adeguatamente trattati e smaltiti in modo sicuro, i rifiuti elettronici sono una fonte di contaminazione delle acque superficiali e sotterranee, dei suoli e atmosfera, con impatti negativi sull'intero ambiente [6]. Le strategie basate sull'assorbimento, di cui il gruppo di ricerca ha esperienza documentata e scientifica [7-12], sono state recentemente impiegate come alternative a basso costo. In questo contesto, i sorbenti a base di carbonio possono essere facilmente ottenuti riutilizzando la biomassa di scarto, fornendo un'unica opportunità per trasformarli in ricchezza [13]. Inoltre, pochi modelli per la progettazione razionale di sorbenti target selettivi e pochi studi si sono concentrati sulla sostituzione dei tradizionali solventi utilizzati per il desorbimento e il recupero di cationi metallici concentrati in fasi solide con alternative verdi (ad es. DES o liquidi ionici) [14,15]. Eppure una strategia integrata per il trattamento dei rifiuti che porta al riutilizzo circolare, dove il fine vita le merci diventano materia prima riciclata è ancora mancante. |
| Descrizione del progetto                                                                 | Il gruppo di ricerca che guida questo progetto impiegherà una combinazione di metodi sperimentali e computazionali per studiare l’adsorbimento sfruttando la loro vasta esperienza in questo campo. Saranno inoltre condotti test di estrazione utilizzando ICP-OES per analizzare il contenuto totale di metallo estratto con i nanomateriali, ma anche estratti dagli stessi grazie ai DES. Basandosi su studi precedenti condotti dal gruppo di ricerca [7-12], varie tecniche come la spettrofotometria UV-Vis e la calorimetria saranno utilizzate per la cinetica, la termodinamica di interazione tra i nanomateriali e i CRM, per definire il meccanismo di assorbimento, l'equilibrio e l'entalpia di assorbimento. Il gruppo di ricerca ha dimostrato competenza nell'utilizzo di metodi teorici [14, 16] per studiare i complessi metallici del blocco d e gli elementi delle REE in soluzione [17]. I calcoli quantomeccanici saranno impiegati per esaminare la formazione complessa in soluzione, comprendersi la determinazione della geometria, l'analisi della stabilità degli isomeri e l'interpretazione dei dati termodinamici sperimentali. L'approccio teorico primario sarà basato sulla teoria del funzionale densità (DFT), inclusa la sua estensione, DFT dipendente dal tempo (TDDFT), utile per il calcolo degli stati eccitati. Oltre ai calcoli “statichi”, il team di ricerca esplorerà gli effetti dinamici attraverso simulazioni che utilizzano la dinamica molecolare classica (MD) e/o calcoli dei principi primi (AIMD). Queste simulazioni consentiranno l'osservazione dell'evoluzione temporale delle specie metalliche in soluzione e l'adsorbimento sulla superficie dei nanomateriali. Metodologie simili sono state impiegate con successo dal gruppo di ricerca in precedenti studi che coinvolgono altri metalli [15]. |
| Possibili potenzialità applicative                                                                 | Lo scopo principale di questo progetto è raccogliere dati cinetici e termodinamici essenziali sull’estrazione e la separazione di elementi delle REE utilizzando nanomateriali multifunzionali all'avanguardia. Inoltre, il progetto mira a sviluppare metodi efficienti per recuperare questi metalli adsorbiti utilizzando DES. I risultati della ricerca avranno implicazioni significative per la creazione di sistemi di riciclaggio economicamente fattibili e sostenibili dal punto di vista ambientale, con l'obiettivo di ridurre la dipendenza da materie prime di nuova provenienza. Inoltre, il progetto riconosce l'importanza cruciale del riutilizzo delle terre rare, fornendo così un prezioso contributo al progresso dei principi dell'economia circolare. |
| Bibliografia                                                                 | [1] "Critical Raw Materials for Strategic Technologies and Sectors in the EU, A Foresight Study" 09/2020  
[7] Processes (2023) 11(2),472*  
[8] Processes (2021) 9(11),1873*  
[10] RSC Adv. (2016) 6, 42288*  
Abstract
The project deals with the design and development of new nanomaterials, based on recycled material from waste biomass, able to detect, bind and extract critical raw materials (CRM) such as Nd, Dy and Pd from solutions that simulate electronic waste. Once absorbed, green solvents such as Deep Eutectic Solvents (DES) will be tested for desorption as an alternative to the classic treatment. To this end, thermodynamic and kinetic models will be used to define the absorption mechanism, constant equilibrium and rate, and absorption enthalpy. Computational methods will be used to support the interpretation of the experimental data and guide the design of the absorbent materials. The project will connect waste from food production cycles with those from the digital supply chain, creating a new (bi)cycle at an even higher level. The project aims at social and economic improvement as it will have to address issues such as waste management, circular economy and recovery of CRMs.

Objectives of the project
The aim of this project is to evaluate the feasibility of using new multifunctional materials based on biomass recycled materials for CRM recovery from simulated e-waste solutions. The project has two main objectives: a) valorization of waste biomass; b) development of new sustainable protocols to recover CRM. To achieve this goal, it is essential to determine the kinetics and thermodynamics of the complexes in the extraction and separation processes. This will be achieved through a combination of experimental and computational methods. Subsequently, we will proceed with the recovery of CRM adsorbed on biomaterials thanks to DES.

State of the art
According to ISMEA 2021 data, in Italy the amount of waste from the agri-food chain of olives, citrus fruits, grapes and nuts is around 4000 kty. New approaches to manage waste biomass are hot topics for applied research and government programs, as shown, for example, in Italy by the "PNRR, Mission 2C1, Circular economy and sustainable agriculture". In parallel, the EU has set up several CRMs as they will have growing importance for several strategic sectors (e.g., e-mobility, defence, electricity generation, electronics) in the coming years and their supply is associated with high risk [1]. Among them, rare earth elements (REE) and platinum group metals (PGMs) are among the most crucial. The information and communication technology (ICT) industry, for example, requires raw materials that are scarcely available in nature or located in politically unstable areas [2]. The EU largely depends on other countries for high-tech components and assembles; Furthermore, the recovery of CRM from ICT technologies is currently affected by their limited recycling potential, due to bad industrial designs and poor separation selectivity towards mixtures of elements [3,4]. In this context, the dual objective of reducing the amount of waste and developing new sustainable and efficient recycling protocols is mandatory to mitigate the effect of the crisis due to the scarcity of CRM, geopolitical problems and consumption of new resources. Processes aimed at the recovery of high-

value compounds are a golden opportunity to valorise waste as urban mines [5]. On the other hand, if not properly treated and disposed of safely, electronic waste is a source of contamination of surface and groundwater, soils and the atmosphere, with negative impacts on the entire environment [6]. Uptake-based strategies, of which the research group has documented and scientific experience [7-12], have recently been employed as low-cost alternatives. In this context, carbon-based sorbents can be easily obtained by reusing waste biomass, providing an effective opportunity to transform them into wealth [13]. Furthermore, few models for the rational design of selective target sorbents and few studies have focused on the replacement of traditional solvents used for desorption and recovery of concentrated metal cations in solid phases with green alternatives (e.g., DES or ionic liquids) [14,15]. Yet an integrated waste treatment strategy leading to circular reuse, where end-of-life goods become recycled raw material is still missing.

| Project description | The research group leading this project will employ a combination of experimental and computational methods to study adsorption by leveraging their extensive experience in this field. Extraction tests will also be conducted using ICP-OES to analyze the total metal content extracted with nanomaterials, but also extracted from them thanks to DES. Building on previous studies conducted by the research group [7-12], various techniques such as UV-Vis spectrophotometry and calorimetry will be used for the kinetics, thermodynamics of interaction between nanomaterials and CRMs, to define the absorption mechanism, the equilibrium and the enthalpy of absorption.

The research group has demonstrated proficiency in using theoretical methods [14, 16] to study d-block metal complexes and REE elements in solution [17]. Quantum mechanical calculations will be employed to examine the complex formation in solution, including the determination of the geometry, the analysis of the stability of the isomers and the interpretation of the experimental thermodynamic data. The primary theoretical approach will be based on density functional theory (DFT), including its extension, time-dependent DFT (TDDFT), useful for the computation of excited states.

In addition to 'static' calculations, the research team will explore dynamic effects through simulations using classical molecular dynamics (MD) and/or first principles calculations (AIMD). These simulations will allow the observation of the temporal evolution of the metallic species in solution and the adsorption on the surface of the nanomaterials.

Similar methodologies have been successfully employed by the research team in previous studies involving other metals [15]. |

| Possible application potentialities | The primary aim of this project is to gather essential kinetic and thermodynamic data on the extraction and separation of rare earth elements (REEs) using state-of-the-art multifunctional nanomaterials. Additionally, the project aims to develop efficient methods for recovering these adsorbed metals using Deep Eutectic Solvents (DES). The research findings will hold significant implications for the establishment of recycling systems that are economically feasible and environmentally sustainable, aiming to decrease reliance on newly sourced raw materials. Furthermore, the project acknowledges the crucial significance of reusing REEs, thereby making a valuable contribution to the advancement of circular economy principles. |
| References | [1] "Critical Raw Materials for Strategic Technologies and Sectors in the EU, A Foresight Study" 09/2020  
[7] Processes (2023) 11(2), 472*  
[8] Processes (2021) 9(11), 1873*  
[10] RSC Adv. (2016) 6, 42288*  

*articles of the Principal Investigator

Struttura dell'Università di Udine presso la quale verrà sviluppata l'attività di ricerca / Department or other structure of the University of Udine where research activities will be carried out:

Dipartimento Politecnico di Ingegneria e Architettura (DPIA) / Polytechnic Department of Engineering and Architecture

Importo dell’assegnio di ricerca (al lordo oneri carico assegnista) / Total grant gross for the research fellowship:

€ 19,367,00

Durata dell’assegnio di ricerca / Duration of the research fellowship “assegno di ricerca”:

12 mesi / months

Finanziamento / Financed by:

La copertura finanziaria graverà sui fondi/progetto:

- Risorse d’Ateneo: bando interno finanziamento assegni 2023 (D.R. n. 406/2023);  

Requisiti di ammissione / Minimum qualifications necessary:

- Possesso del titolo di Dottore di ricerca o titolo equivalente conseguito all’estero;  
- possesso di un curriculum scientifico professionale idoneo allo svolgimento dell’attività di ricerca contemplata.  
- Research doctorate or equivalent qualification obtained abroad;  
- professional scientific curriculum suitable for the research activity above mentioned.
Procedura selettiva / Competition procedure:

Valutazione per titoli e colloquio / Evaluation of titles and oral exam

I risultati della valutazione dei titoli saranno resi noti agli interessati nel corso del colloquio / The evaluation of the qualifications will be disclosed to candidates during the interview

<table>
<thead>
<tr>
<th>Calendario del colloquio / Calendar of the oral exam</th>
<th>Modalità / Modality</th>
<th>Videoconferenza / Videoconference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data / Date</td>
<td>23 novembre / November 2023</td>
<td></td>
</tr>
<tr>
<td>Ora / Time</td>
<td>11:00 / 11:00 am (Italian time)</td>
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<tr>
<td>Luogo / Place</td>
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Per sostenere il colloquio i candidati devono esibire un valido documento di riconoscimento. / Candidates must come to the interview with a valid identity document.

Eventuali variazioni saranno rese note esclusivamente mediante pubblicazione all’albo ufficiale on line dell’Ateneo / Any change will be made public solely through publication on the University web site http://web.uniud.it/ateneo/normativa/albo_ufficiale

Nota / Note: Le indicazioni sulle modalità di svolgimento della prova in modalità telematica saranno inviate ai candidati con successiva email da parte del Presidente della Commissione. Ai fini dell’identificazione e a pena di esclusione dalla procedura selettiva, ciascun candidato è tenuto ad identificarsi prima che il colloquio abbia inizio, esibendo il medesimo documento di identità allegato alla domanda di ammissione al concorso. Il candidato deve risultare reperibile nella giornata e all’orario indicato sul bando. Il mancato collegamento, l’irreperibilità del candidato nel giorno o nell’orario stabilito o la mancata esibizione del documento identificativo, sono motivo di esclusione dalla procedura selettiva. La registrazione delle prove orali è vietata. L’Ateneo adotterà pertanto tutti i provvedimenti in suo potere per tutelare i soggetti coinvolti qualora venissero diffuse tramite internet – o altri mezzi di diffusione pubblica – video, audio o immagini della procedura selettiva. / Instructions on how the video interviewing will be conducted will be provided to candidates by the Chairman of the Examining Board via email. For identification purposes, each candidate is required to identify him/herself before the interview by exhibiting the same identification document attached to the application. Candidates must be available on the day and time established by the call for applications. Failure of the candidate to establish a video connection, the unavailability of the candidate on the day and/or time established or failure of the candidate to provide the required identification document are all grounds for exclusion from the selection procedure. Recording of the video interviews is prohibited. The University will adopt all the measures within its power to protect all personnel involved as a result of dissemination via the internet or via other forms of public dissemination, of videos, audios or other pictures of the selection procedures.
### Commissione giudicatrice / Examining Board:

<table>
<thead>
<tr>
<th>Nome e Cognome</th>
<th>Qualifica</th>
<th>SSD</th>
<th>Università</th>
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<tbody>
<tr>
<td><strong>Membri Effettivi / Permanent members</strong></td>
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</tr>
<tr>
<td>Marilena Tolazzi</td>
<td>PO</td>
<td>CHIM/07</td>
<td>Università degli Studi di Udine</td>
</tr>
<tr>
<td>Andrea Melchior</td>
<td>PA</td>
<td>CHIM/07</td>
<td>Università degli Studi di Udine</td>
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<tr>
<td>Sara Colussi</td>
<td>PA</td>
<td>ING-IND/27</td>
<td>Università degli Studi di Udine</td>
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<tr>
<td><strong>Membro Supplente / Temporary member</strong></td>
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<tr>
<td>Francesco Andreatta</td>
<td>PA</td>
<td>ING-IND/22</td>
<td>Università degli Studi di Udine</td>
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