# RECYCLING OF GREEN PLANT WASTE – PRODUCTION OF IRON NANOPARTICLES


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## Introduction

Zero-valent iron nanoparticles (nZVI) have already proven their efficacy in the reductive degradation of a wide range of environmental contaminants. However, their large-scale application in remediation applications is hindered by the high costs and the environmentally and legislative issues associated with the conventional nZVI synthesis method as it places a massive burden on the environment by utilizing toxic chemicals for the production process and leaving hazardous waste materials behind. On these grounds, green synthetic approaches have emerged, offering eco-friendly, sustainable, nature-derived alternative production methods, thus attenuating the ecological footprint of the nanomaterial industry.

## Objectives

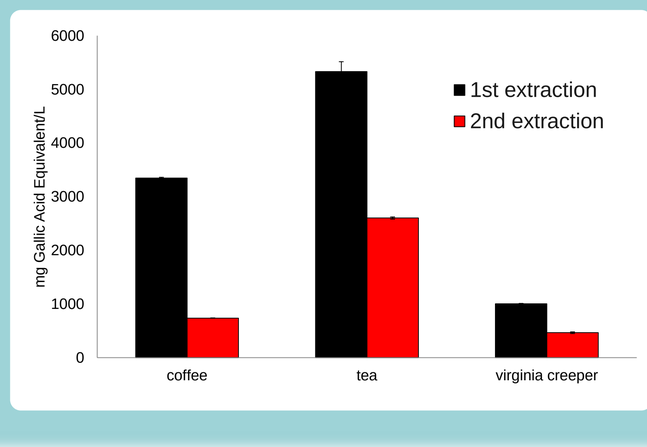
In this connection, the aim of our present work was to further develop green syntheses from an innovative, economic and environmental point of view, primarily by involving plants that are widely available and easily accessible, and through their use the synthesis can be carried out on an industrial scale. We investigated the possibility of recycling of green plant waste materials, namely whether these waste materials can be used multiple times for particle synthesis.

## Characterization of extracts

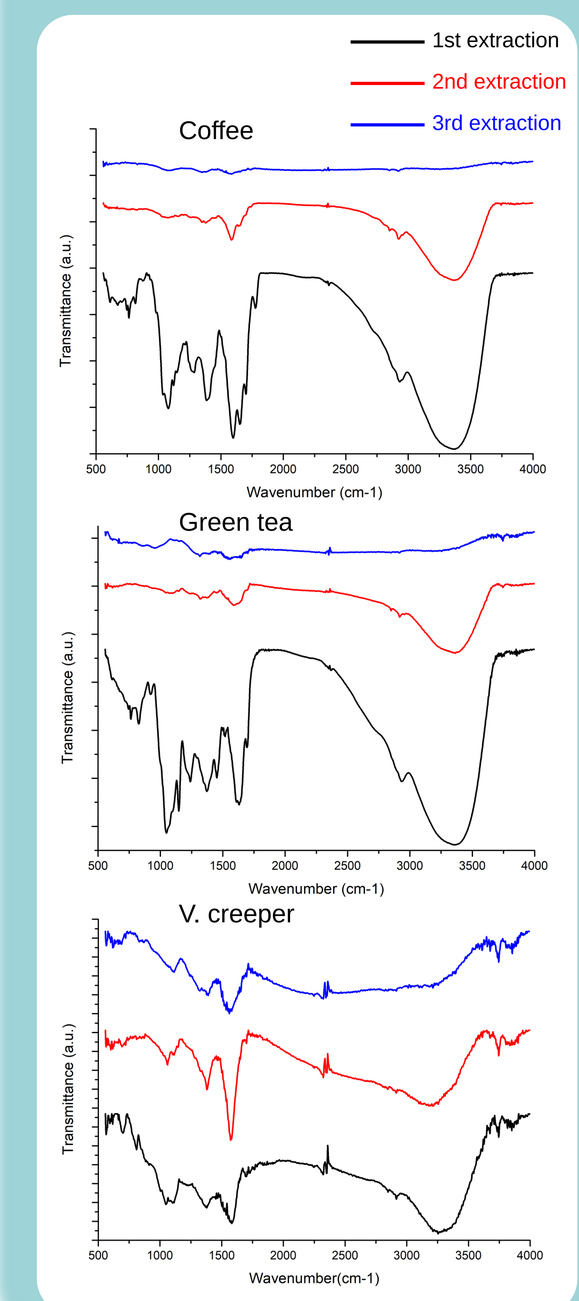
### HPLC – Sugar content

| Sample | Maltose | Glucose | Xylose | Mannitol |
|---|---|---|---|---|
| Green tea | 385.9 | 567.3 | 447.6 | 620 |
| Coffee | 0 | 0 | 0 | 213.6 |
| V. creeper | 0 | 1598.1 | 3570.5 | 0 |

### Phenolic content

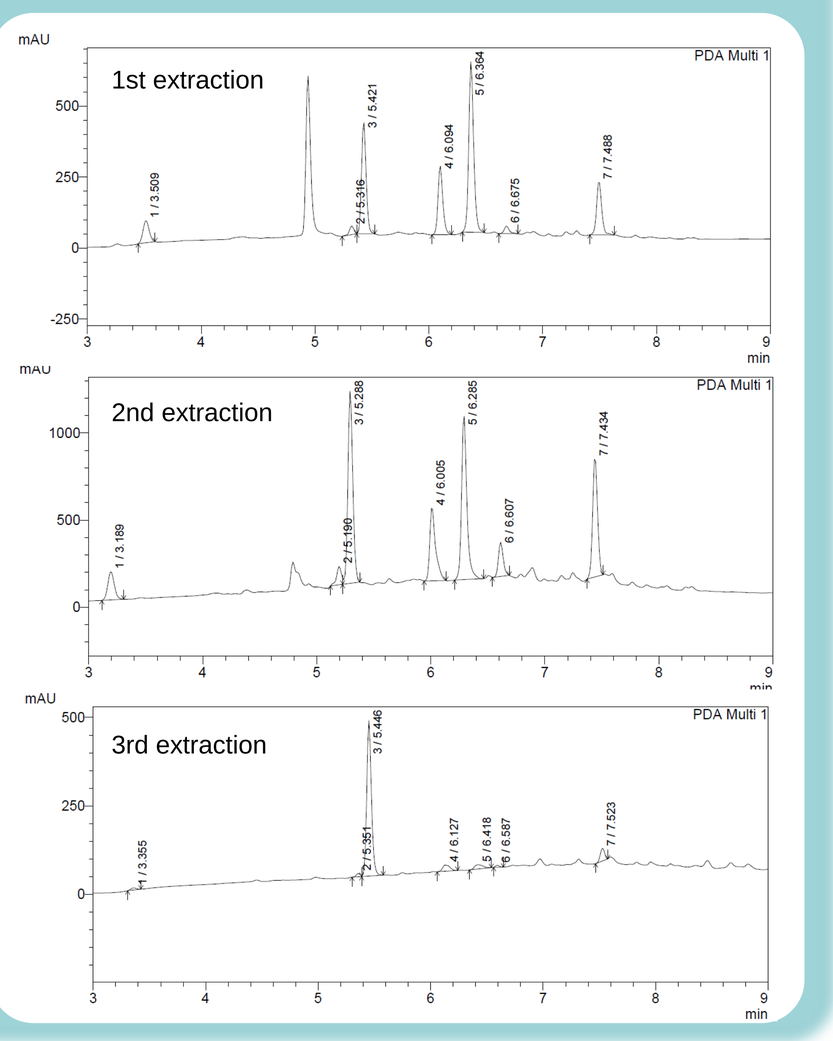



## Infrared spectroscopy




## GC MS – Green tea

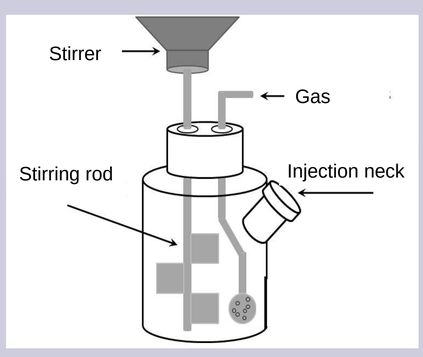
| Peak # | Component | Concentration (µg/mL) | | |
|---|---|---|---|---|
| | | 1st | 2nd | 3rd |
| 1 | (-)-gallocatechin | 221.9 | 44.3 | 4.8 |
| 2 | (+)-catechin | 44.9 | 16.9 | 1.3 |
| 3 | coffein | 773.1 | 228.8 | 88.9 |
| 4 | (-)-epicatechin | 413.5 | 86.3 | 5.6 |
| 5 | (−)-gallocatechin-3-gallate | 1400.3 | 234.2 | 9.2 |
| 6 | (−)-epigallocatechin-3-gallate | 106.4 | 43.6 | 6.0 |
| 7 | (−)-catechin-3-gallate | 352.8 | 120.4 | 7.3 |
| 8 | (−)-epicatechin-3-gallate | - | - | - |




## nZVI synthesis

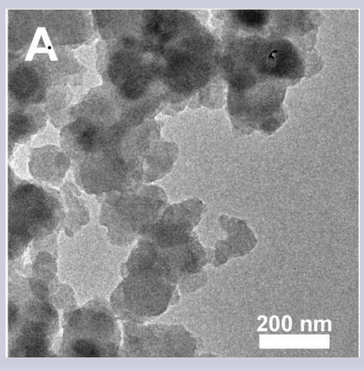
The green material extracts were analyzed with analytical methods to determine main components involved in nanoparticle synthesis. The formed nZVIs were subjected to detailed material science characterization (e.g., transmission electron microscopy, surface area and reactivity test).

| Sample | Precursor | Reducing agent |
|---|---|---|
| A | $FeCl_2$ | Green tea |
| B | FeCl2 | Coffee |
| C | $FeCl_2$ | Virginia creeper leaf |

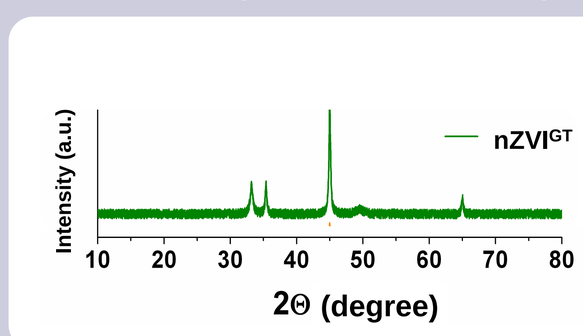



## Characterization of nanoparticles

### Transmission electron microscopy (TEM)




### X-ray Powder Diffraction (XRD)




## Results

We successfully carried out the synthesis of iron nanoparticles using multiple times the coffee and green tea extracts during the procedure. Based on our comprehensive screening, we delineated major differences in the characteristics of the obtained materials. Moreover, we analyzed the changes in main components involved in nanoparticle synthesis (e.g., proteins, sugars, polyphenols).

## Conclusions

We showed that the various green waste materials could be recycled multiple times for generation of iron nanoparticles. However, we proved that the importance of properly selected green waste materials and synthesis methods must be emphasized as they profoundly influence properties of materials and therefore their chemical and biological activity.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