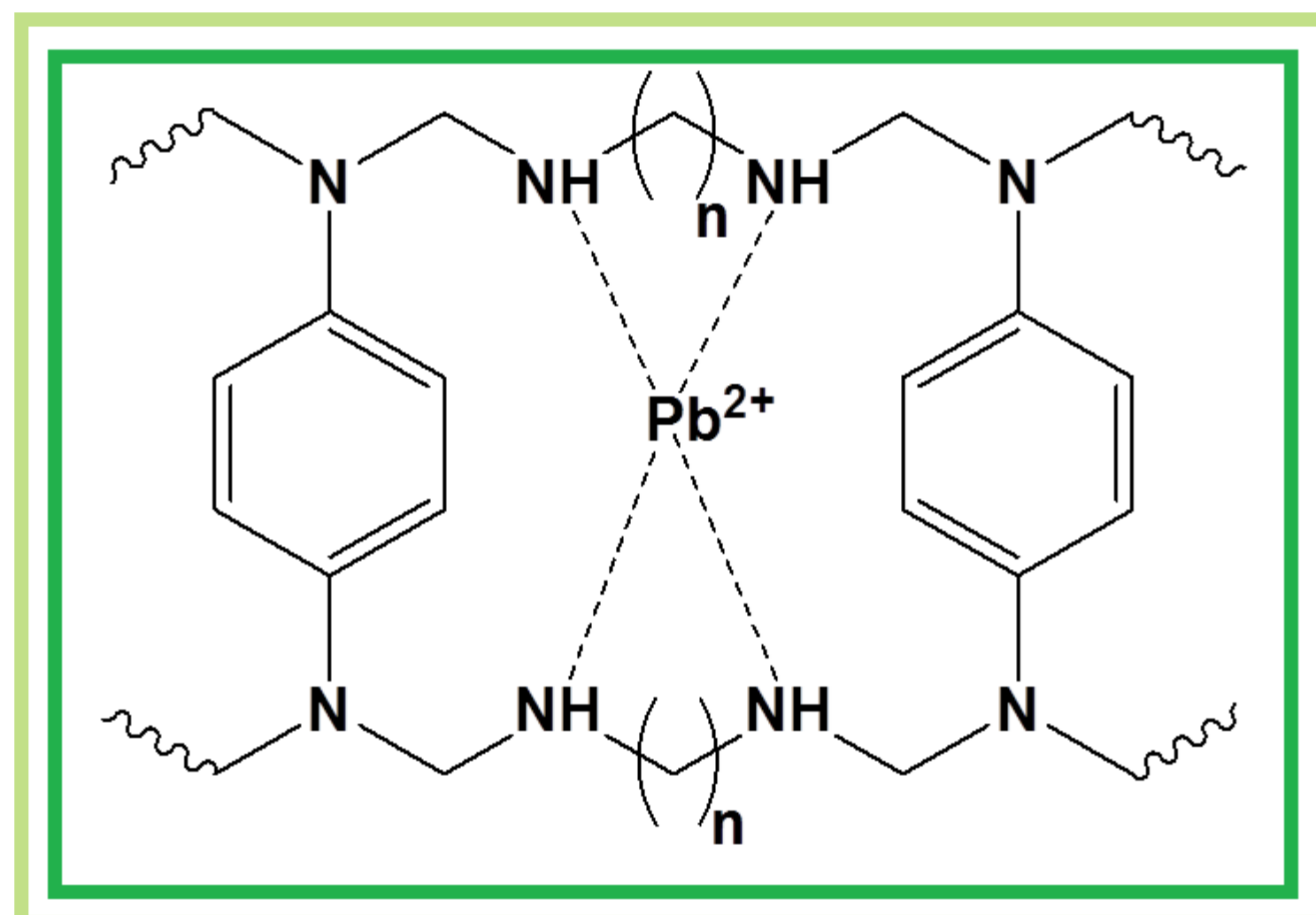


## Abstract

A new series of cross-linked polyamines synthesized by Mannich protocol polycondensation reaction of benzene-1,4-diamine with various alkyldiamines linked with paraformaldehyde. The polymers produced were characterized by solid state  $^{13}\text{C}$ -NMR, FT-IR, elemental analysis. Thermal properties were investigated by thermogravimetric analysis. Crystallinity was investigated by powder x-ray diffraction. Surface morphology was investigated by scanning electron microscopy. Initial investigation on lead ions removal capabilities revealed that the cross-linked polymer composed of benzene-1,4-diamine and 1,4-diaminobutane copolymer had superior efficacy over the rest of the series with a removal % ~99% of lead ions.

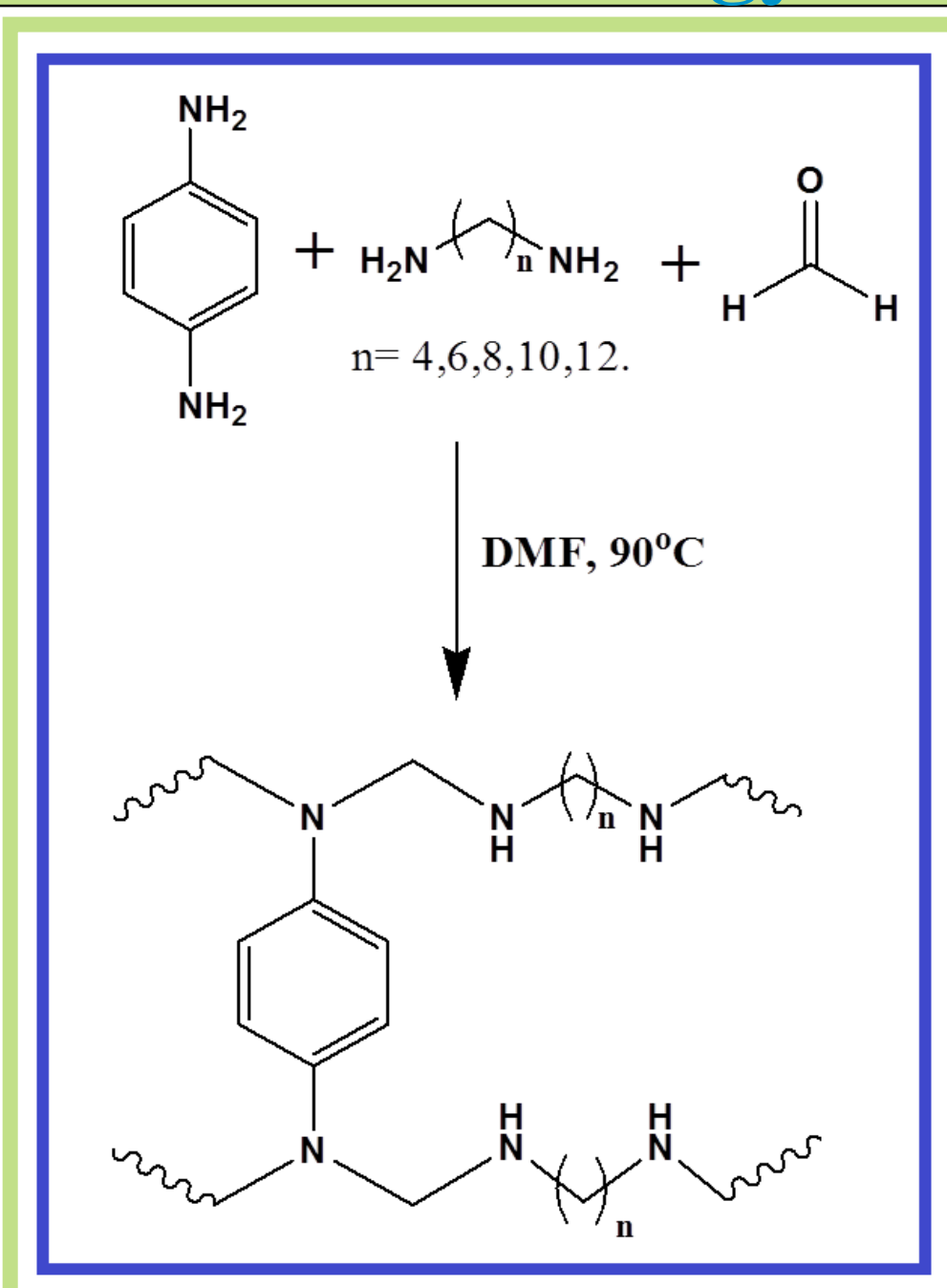


## Introduction

Despite the popular knowledge that over two-thirds of the earth's surface area covered by water, only 2.5% of this is available as freshwater of which ice caps and glaciers locked up to 69% of it; the need to recycle the limited available water is therefore inevitable as failure to do so poses great health risks. Heavy metals (like lead and arsenic) disposed in water from various human activities, especially industrial, even at trace levels, are of potential threat to animals and ultimately to humans as they are non-biodegradable and bioaccumulation in the human body can cause various diseases and disorders [1-5]. Removal of lead is achieved by one or more of the methods like chemical precipitation, adsorption, biosorption, electrodialytic process, ion exchange, ultra-filtration, reverse osmosis, electro-deposition, solvent extraction, foam-flotation, cementation, complexation/sequestration, filtration and evaporation. However, of all these methods, adsorption remains the most attractive due to availability of several low-cost, easily accessible and environmentally friendly adsorbents [6-8].

Lead poisoning is a well-known cause of neurobehavioral-cognitive deficits in children and adolescents [9]. A more recent study shows that early life exposure to lead poses a threat to fetal outcomes at birth and normal fetal growth [10]. Arsenic, on the other hand, has been associated with skin and internal cancer development in humans; Non-carcinogenic effects associated with arsenic are peripheral neuropathy, diabetes, and cardiovascular diseases [11].

## Methodology



Scheme 1: Synthesis of a new series of benzene-1,4-diamine based polyamines.

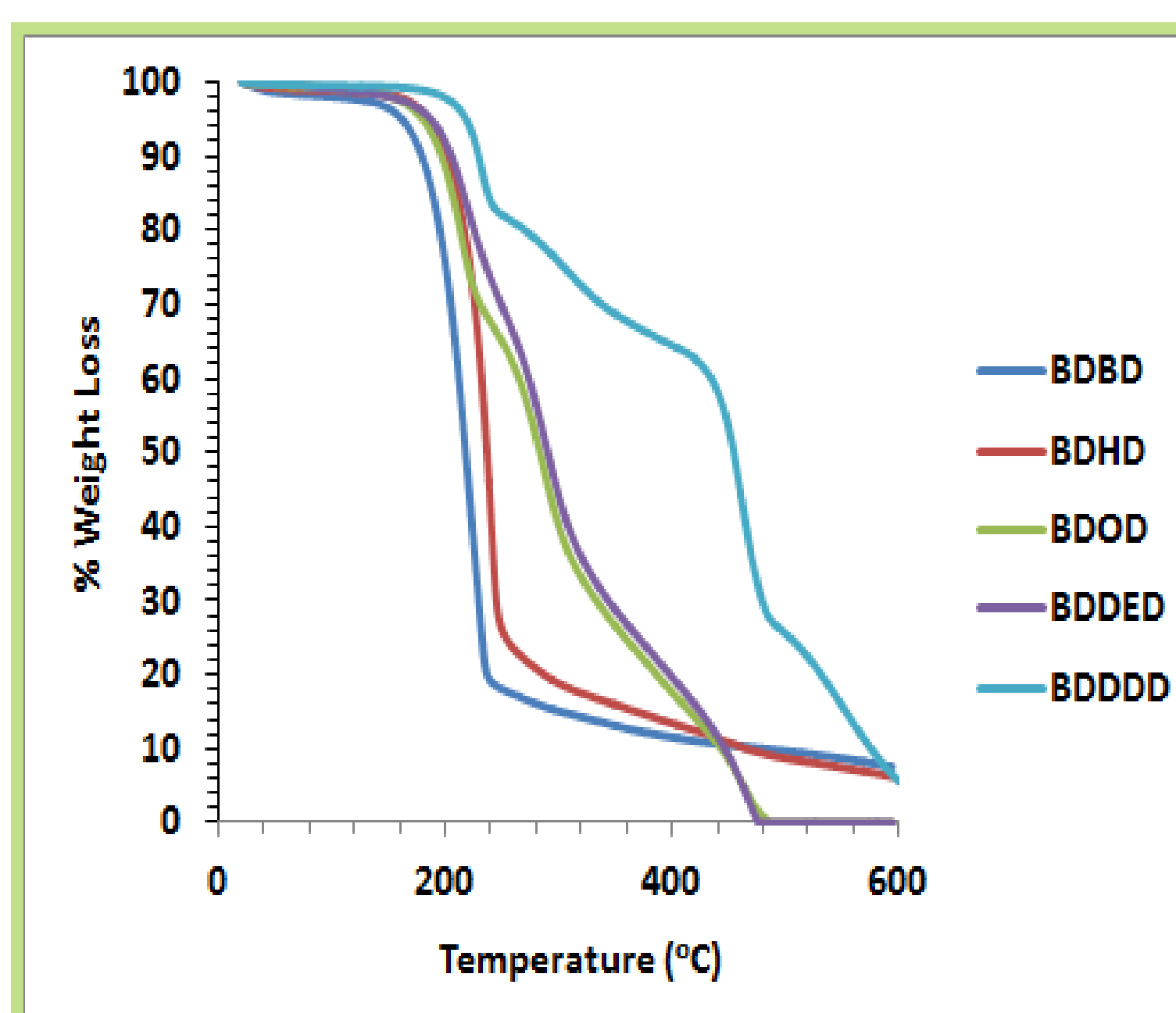
## Results

### (a) Polymer Characterization

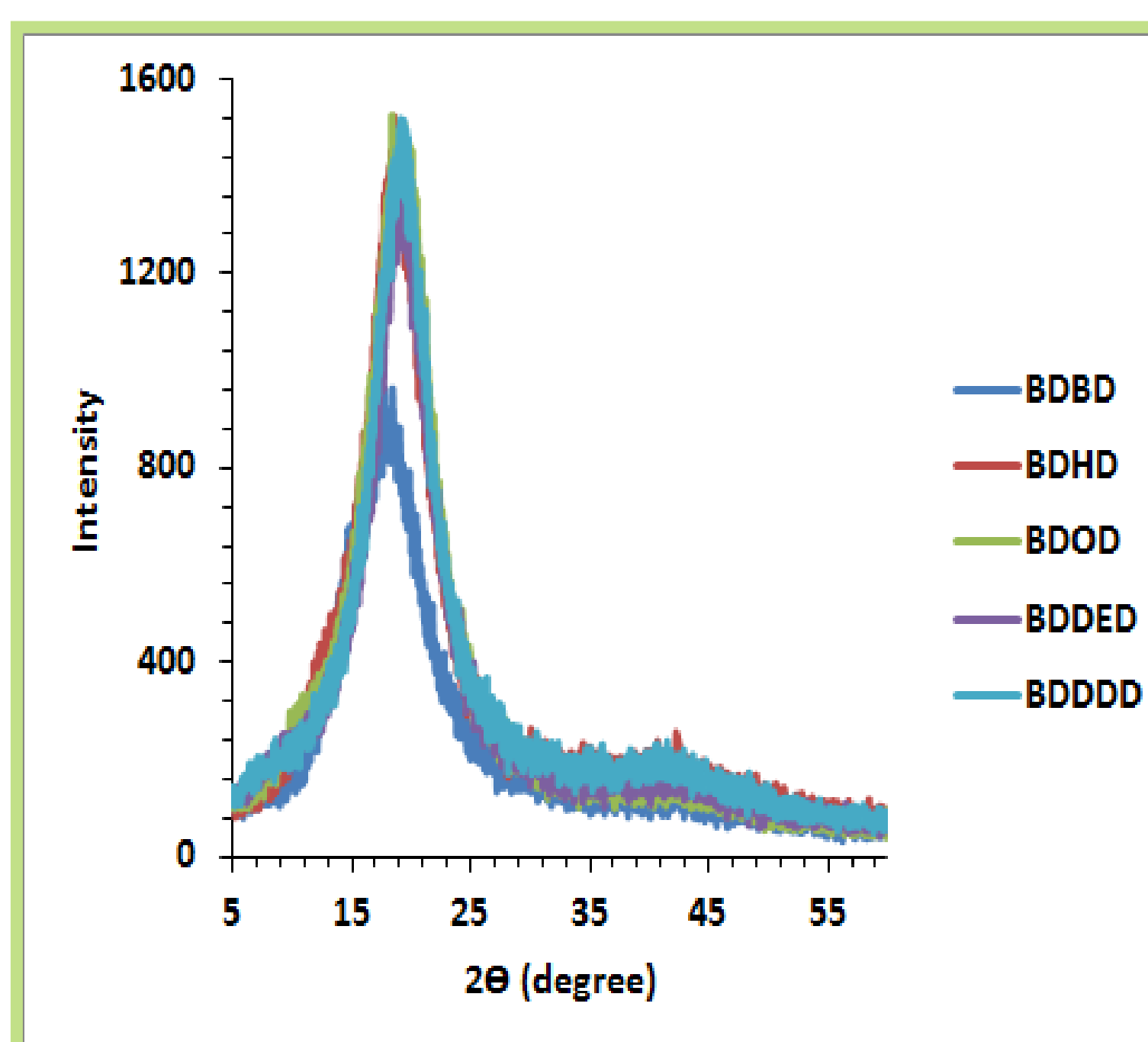
#### a) Elemental Analysis:

| Polymer | Elemental analysis |          |          |
|---------|--------------------|----------|----------|
|         | Carbon             | Hydrogen | Nitrogen |
| BDBD    | 54.17              | 8.44     | 21.83    |
| BDHD    | 66.06              | 10.28    | 20.41    |
| BDOD    | 69.87              | 11.58    | 17.66    |
| BDEED   | 71.89              | 12.31    | 14.95    |
| BDDDD   | 71.96              | 10.19    | 14       |

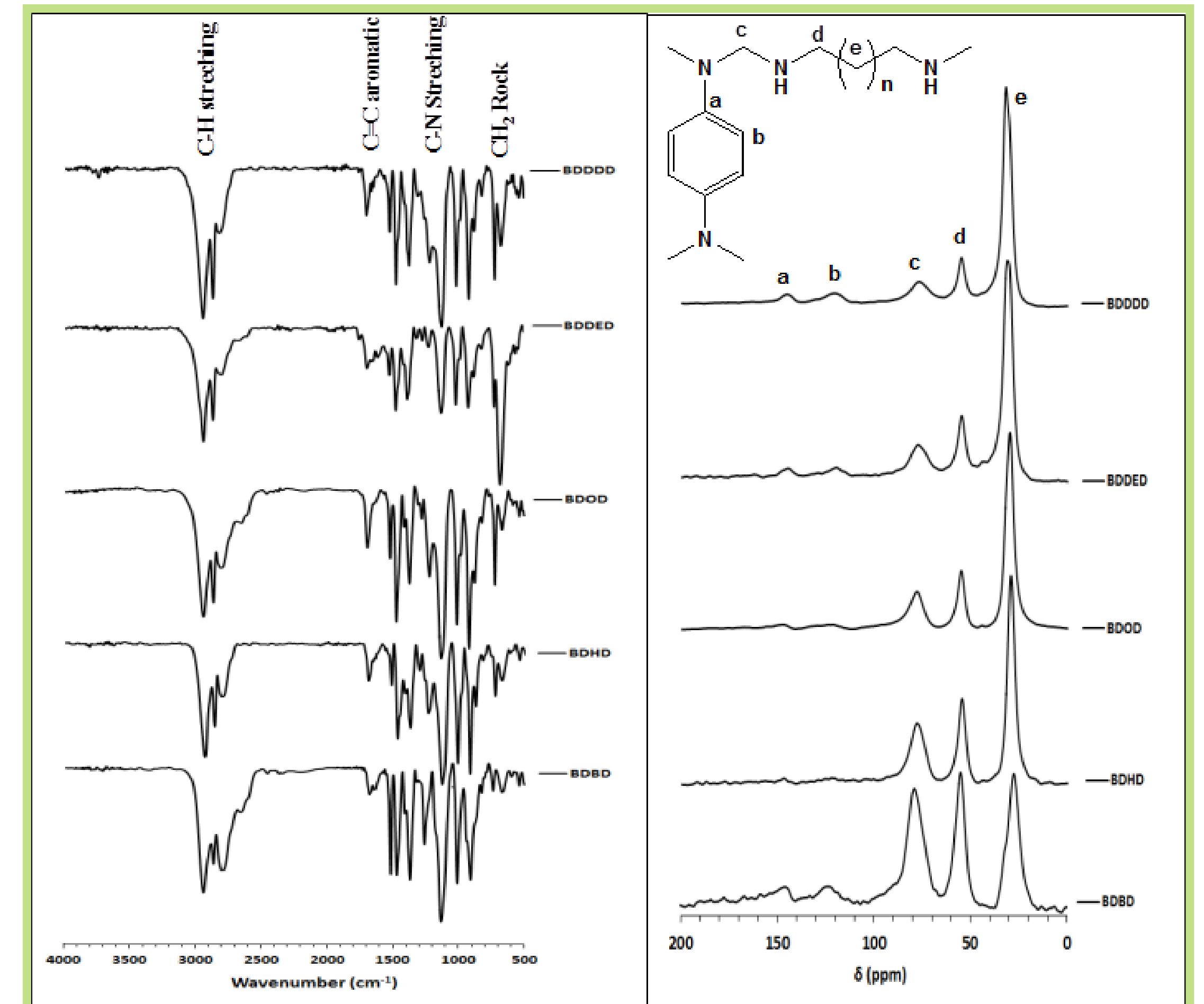
#### c) Thermogravimetric Analysis



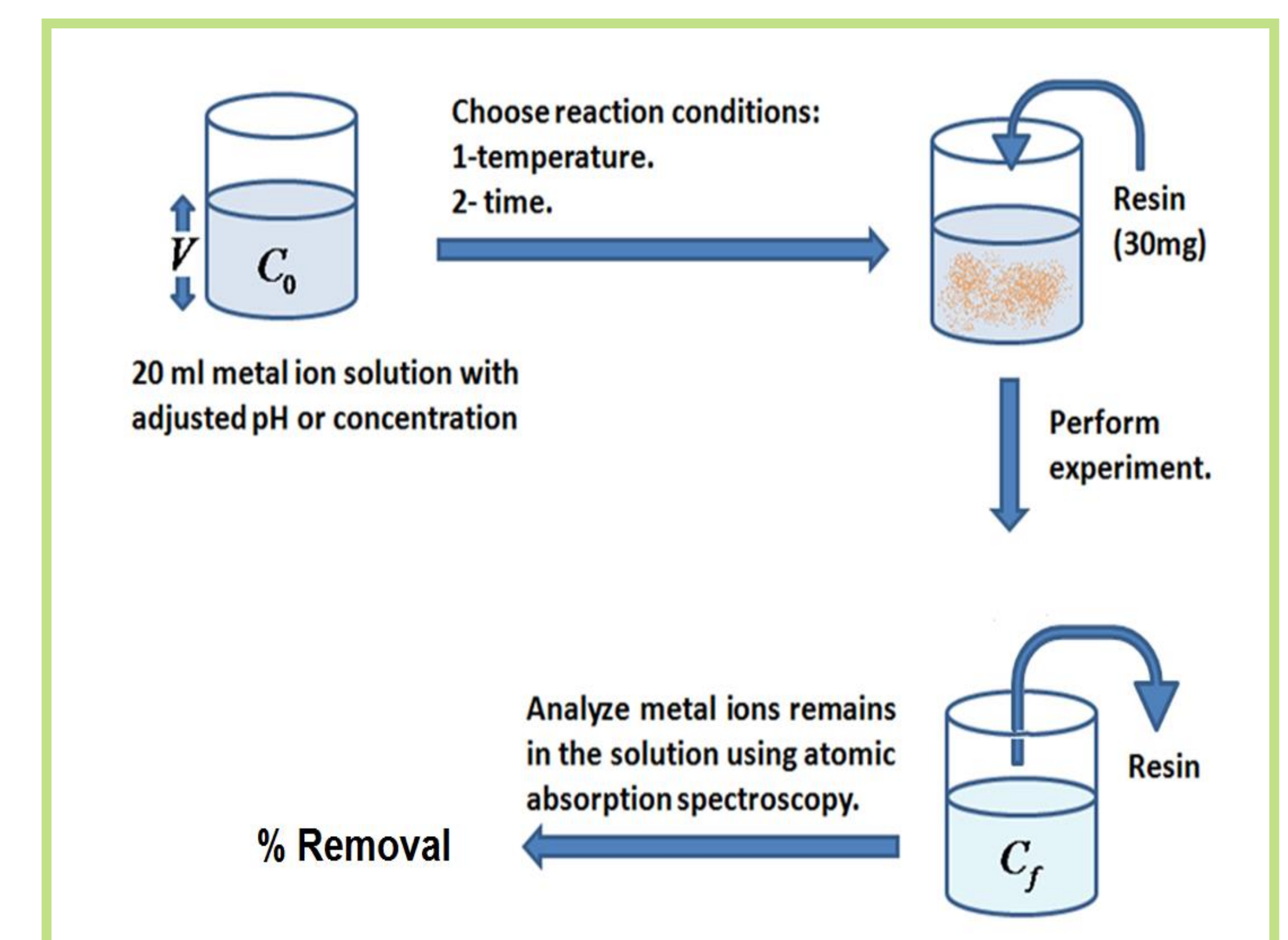
#### (d) Powder x-ray Diffraction:



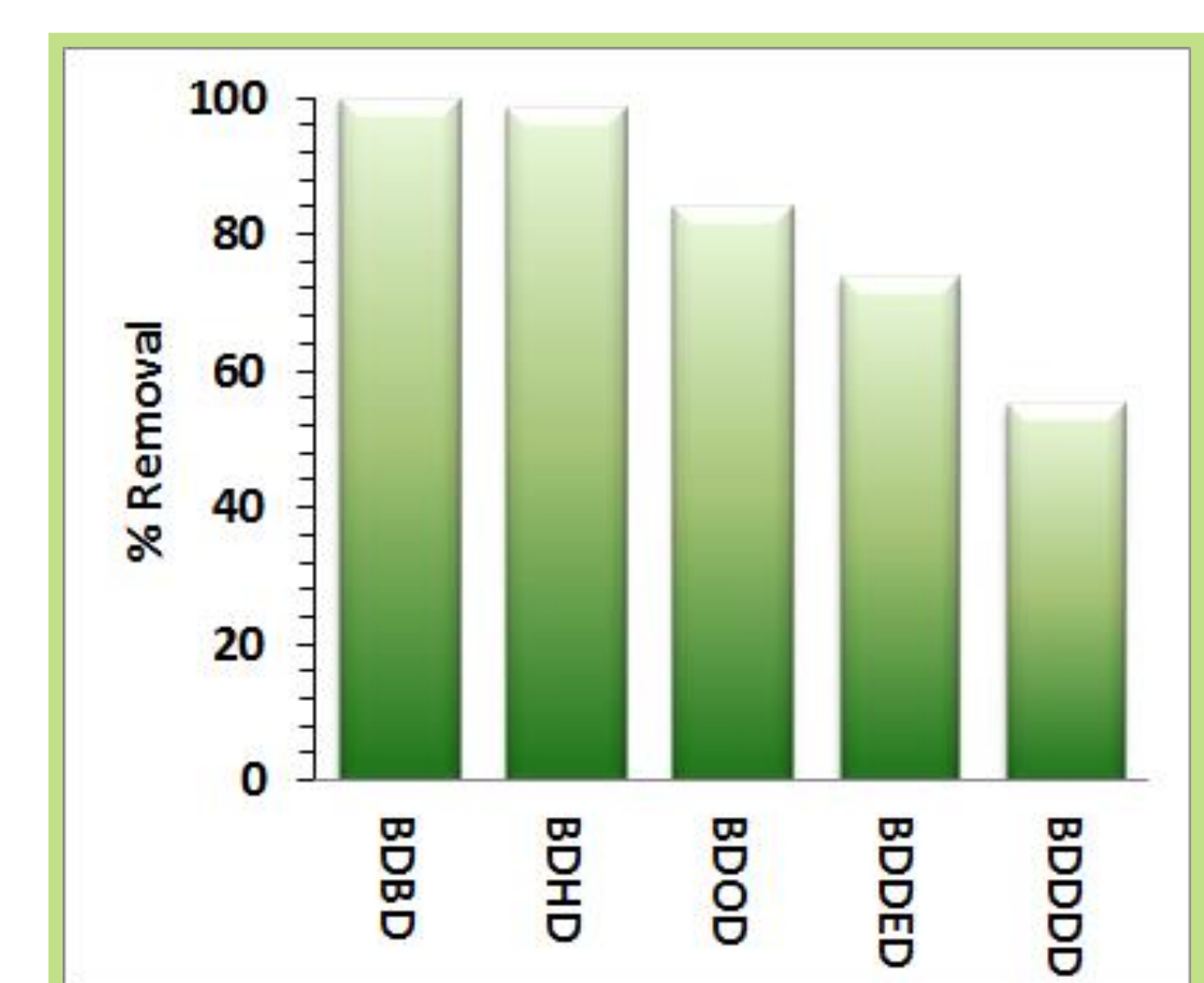
#### (b) FT-IR and $^{13}\text{C}$ -NMR:



### (b) Metal removal



### % Removal of lead (II) ions by the synthesized Polyamines:



## Conclusion

- A new series of polyamines have been synthesized by Mannich polycondensation reaction.
- The new polyamines were amorphous in nature and were stable up to ~200°C.
- The new series showed to be effective in the removal of lead (II) ions from aqueous solutions.

## Acknowledgment

King Fahd University of Petroleum and Minerals (KFUPM) is acknowledged for the general support.

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