

## Background

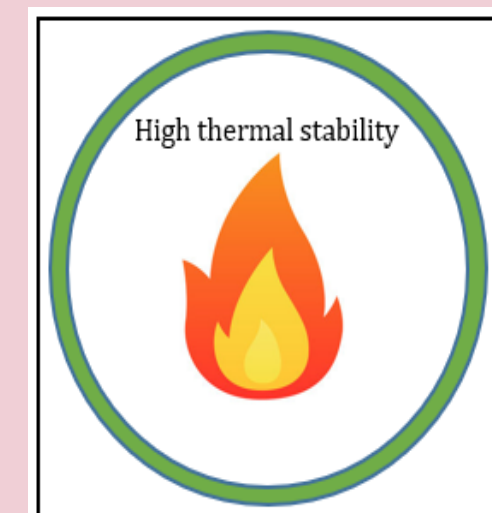
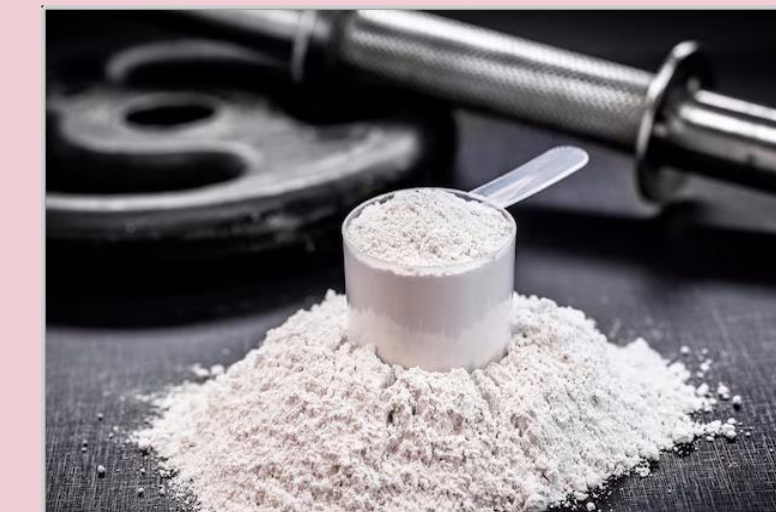
### Problem

- Growing demand for gold has driven the expansion of mining activities globally
- Due to the mining and conventional cyanidation process, environmental concerns have been raised (Aylmore, 2016)
- Led to increased emphasis on non toxic gold lixivants

### Solution

- Use amino acids as promising gold lixivants since discovery in 2014
- Explore the chemistry of complexation, as there is a significant gap in this area
- Utilise amino acids for leaching gold from abundant and cost-effective sources, such as gold tailings

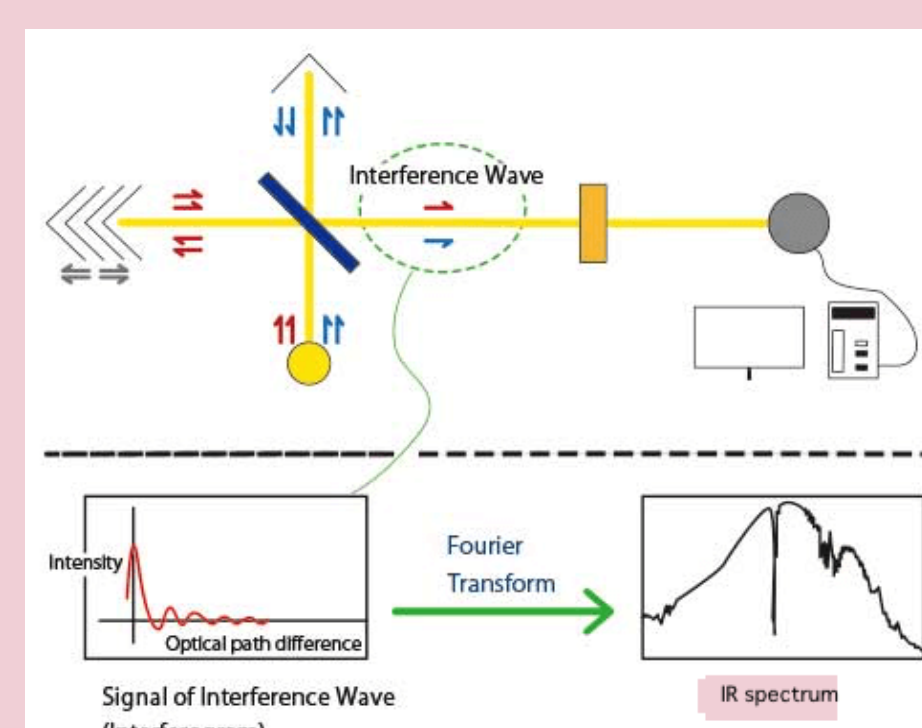
## Advantages of amino acids in gold leaching



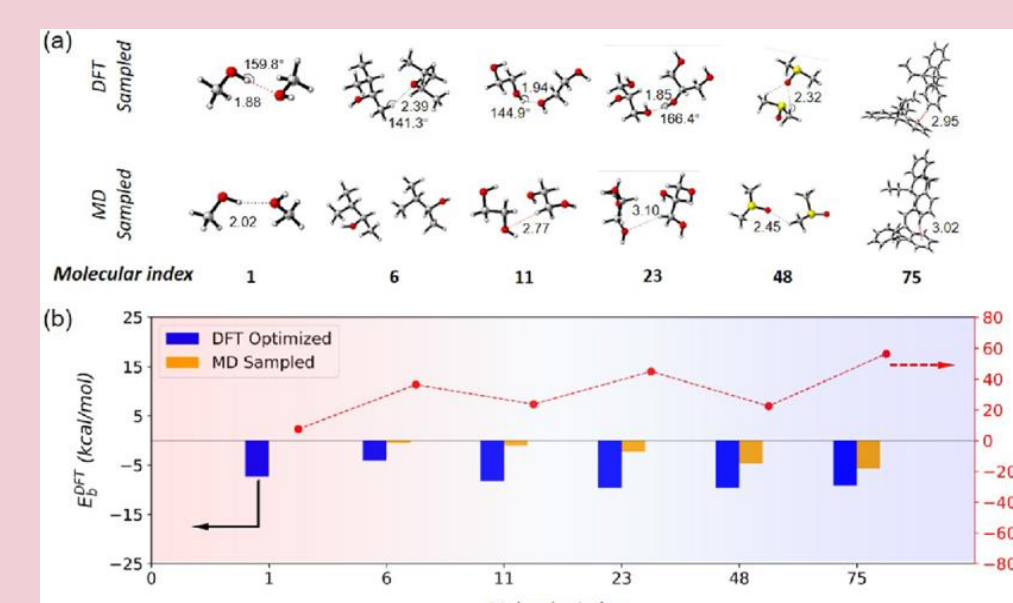
## Study Approach

Proposed Work

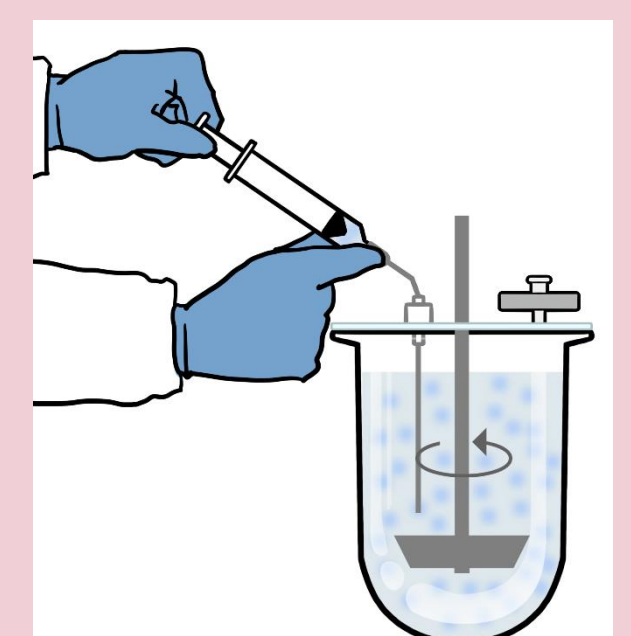
FTIR



DFT



Dissolution studies



## Aim

To conduct a comprehensive investigation into the amino acids in gold leaching as green alternatives to the cyanidation process by looking at the fundamental chemistry application of leaching gold from a secondary gold source

## Objectives

- To understand complex bonding between gold and amino acids using Fourier-transform infrared (FTIR) spectroscopy
- To carry out a study to understand gold-amino acid complexation at a quantum theory modelling level to predict various gold amino acid complexes
- To investigate the leaching of gold from a historical tailing from the West Rand area of the Witwatersrand tailings body to assess the feasibility of using the promising amino acids

## 4. FUTURE WORK

### 1. FTIR and DFT

- More FTIR and DFT investigation on other aliphatic amino acid
- In-depth DFT calculations on the complexes e.g. charge decomposition, Energy Decomposition Analysis (EDA), electron localization function (ELF)

### 2. Gold tailings

- More work on gold ores and tailings of different nature e.g oxidised ore, sulphide, copper-bearing ores etc.

### 3. Downstream processes

- To date, there is no documented work to evaluate the recovery of gold alanine, gold cysteine, and gold histidine complexes into the carbon. Therefore, more need for such recovery investigation on these promising amino acids.

## FTIR

Table 1: The peak vibration shifts on complexation between gold and alanine at two distinct pH points i.e. isoelectric and deprotonation pH

	Peak assignment at isoelectric pH				Peak assignment at deprotonation pH	
	$\nu(\text{NH}_3^+)_{\text{ant}}$	$\nu(\text{COO}^-)_{\text{ant}}$	$\nu(\text{NH}_3^+)_{\text{sy}}$	$\nu(\text{COO}^-)_{\text{sy}}$	$\nu(\text{COO}^-)_{\text{ant}}$	$\nu(\text{NH}_2)_{\text{scissoring}}$
Alanine	1625.99	1593.45	1499.64	1412.08	1591.46	1494.14
Alanine-gold complex	1632.96	disappeared	1485.55	1409.60	1637.97	1500.2
Peak shift	-6.97	-	14.09	2.48	-46.51	-6.06

## DFT

Gold complexes with deprotonated alanine

Gold complexes with zwitterion alanine

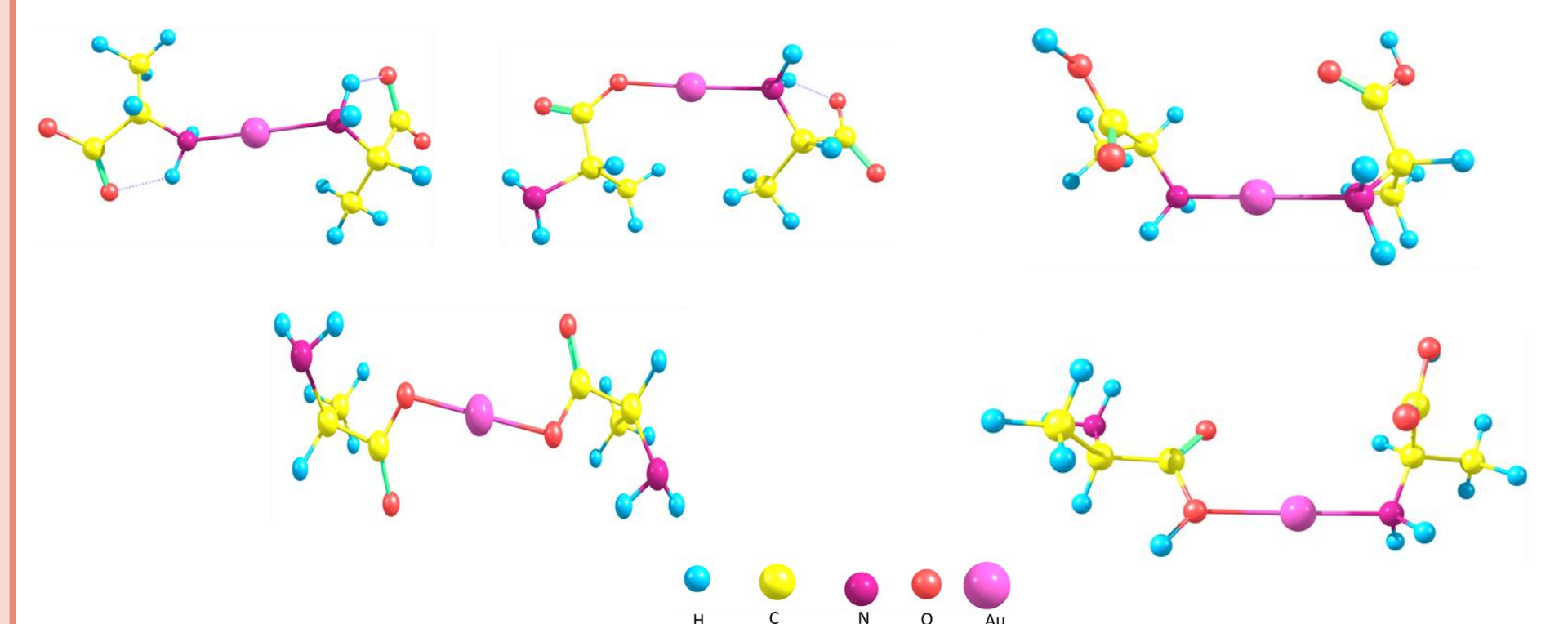


Figure 1: The optimised structures of the complexes that are formed between the gold and (a) deprotonated alanine (b) zwitterion alanine

## Gold tailings leaching

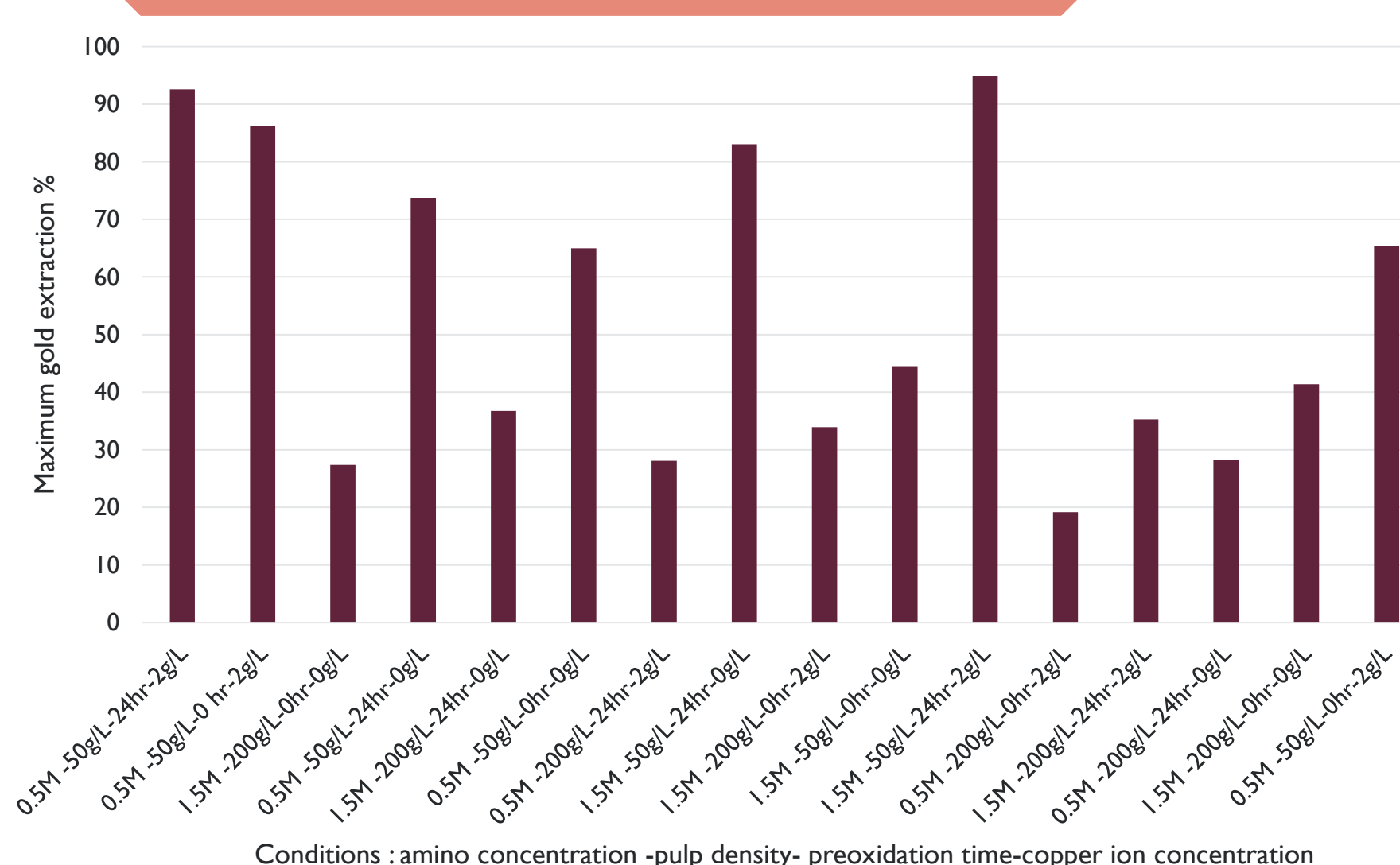


Figure 3: Gold tailing leaching at different conditions with all tests done using deprotonated alanine (pH 12)

## FTIR vs DFT vs Gold dissolution

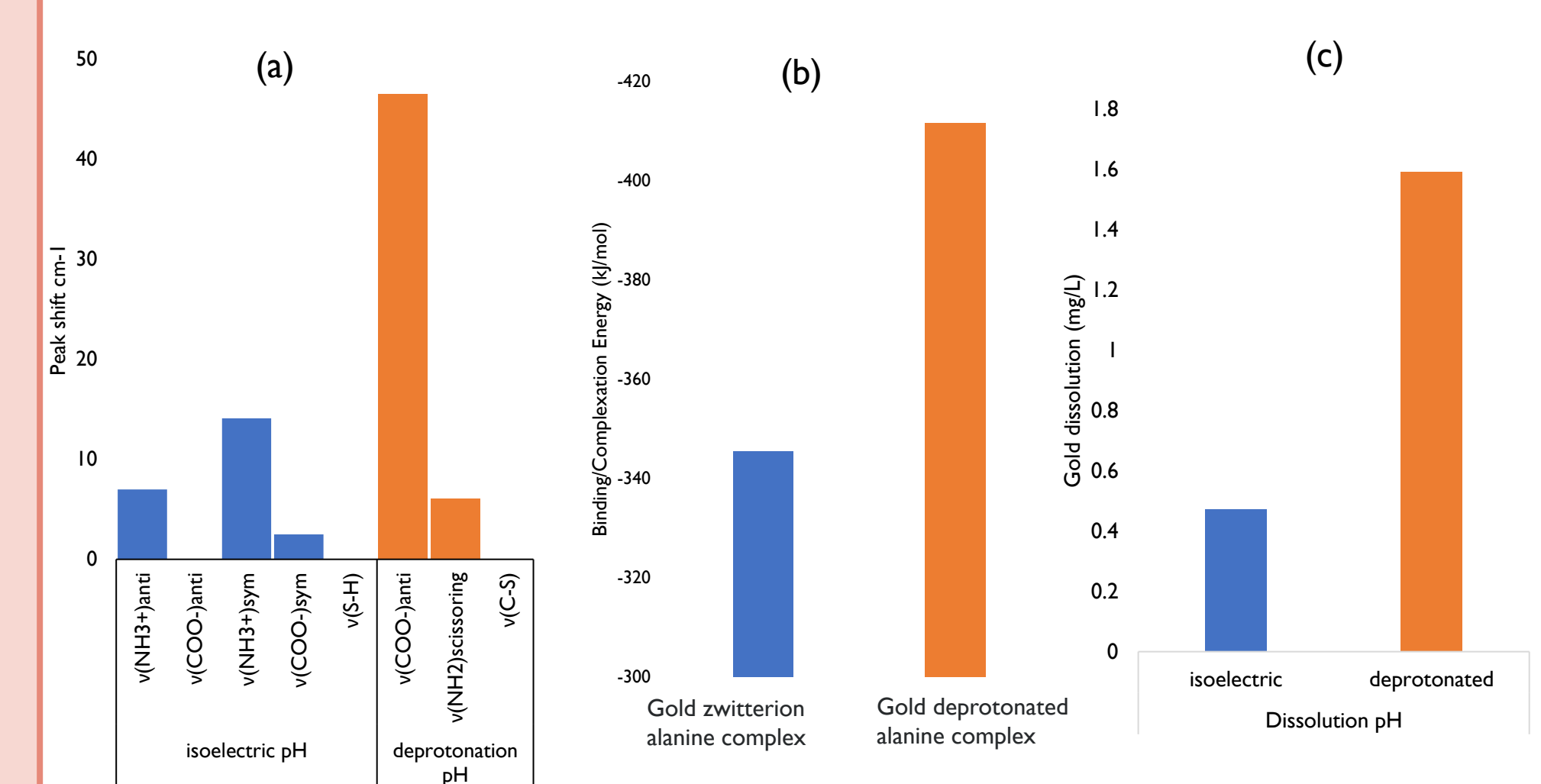


Figure 2: Comparison of the zwitterion and deprotonated alanine in (a) FTIR peak shifts (b) DFT binding energies and (c) pure gold dissolution