

phase, as well as the 2/1 approximant phase. The high strength of these materials makes them suitable for protective coatings. Coatings developed from quasicrystals can provide protection against hydrogen embrittlement of steel parts, which is essential for the implementation of hydrogen-powered engines and the advancement of hydrogen energy technologies. This would help reduce national dependence on natural gas. Additionally, such coatings could extend the service life of the first wall in nuclear and fusion reactors. Quasicrystals possess anomalously low thermal conductivity (3–5 W/m·K) compared to conventional metals. Therefore, Ti-Zr-Ni coatings can be used as effective thermal barriers. Potential applications include protection of aircraft turbojet engine blades, tank gas turbine engines, and internal combustion engine valves. Quasicrystalline Ti-Zr-Ni coatings are also expected to enhance surface hardness and strength, particularly for gear rims and transmission shafts.

Conclusions. Thin-film materials based on quasicrystals and approximant phases of the Ti-Zr-Ni system demonstrate high hardness, resistance to hydrogen embrittlement, and low thermal conductivity. The obtained results highlight the potential of such coatings for use in hydrogen energy, aviation technology, and nuclear/fusion applications. Further research should focus on optimizing the film structure and developing methods for large-scale implementation.

REDUCING THE DIMENSIONALITY OF THE SET OF PREDICTORS FOR PREDICTING THE SOLUBILITY OF IMPURITIES IN COPPER-BASED SOLID SOLUTIONS

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Abstract. This study investigates the use of dimensionality reduction techniques to improve the accuracy of impurity solubility prediction in copper-based alloys. Principal Component Analysis (PCA) and correlation-based distance metrics are combined to identify the most influential predictors and classify solubility behaviour. The proposed approach offers a robust foundation for the development of predictive models in the field of alloy design.

Keywords: solid solution, copper alloys, solubility prediction, dimensionality reduction, PCA, impurity behaviour, the correlation metric.

Introduction. A complex interplay of atomic and thermodynamic parameters governs the solubility of impurities in copper-based solid solutions. Although traditional principles such as Hume-Rothery and Darken-

Gurry have provided valuable insights, their predictive accuracy remains limited. This research aims to enhance predictive capabilities by integrating data-driven techniques with physical property analysis.

- *Object*: Behavior of impurities in binary systems with copper.
- *Subject*: The impact of predictor reduction on solubility modelling accuracy.
- *Goal*: To improve predictive performance by identifying and analysing the most relevant parameters.
- *Novelty*: The application of PCA and correlation-based distance metrics to model impurity solubility within a multidimensional parameter space.

Methodology. The study adopts a modified version of the Fuji conceptual framework, treating copper (Cu) as the reference point ("zero-point") within the predictor space. A comprehensive dataset of physical properties — including atomic radius (Ar), electronegativity (En), valence (Va), melting point (Tm), heat capacity (Cp), Vickers hardness (Hv), elastic modulus (Ec), molar volume (Vm), and Debye temperature (Td) — was compiled for 60 binary copper-based systems.

All data were normalised using z-score standardisation to ensure uniform contribution of each variable. PCA was implemented using Python (NumPy, sci-kit-learn), and the results were visualised with Matplotlib and Seaborn. Correlation-based distance metrics were used instead of Euclidean distances to better account for interdependent parameters

Results.

The first two principal components explained 73.4% of the total variance, confirming the effectiveness of dimensionality reduction. Atomic radius and electronegativity exhibited the highest loading on the first principal component (PC1), reinforcing their significance in predicting solubility behaviour.

In the PCA biplot, elements such as palladium (Pd) and zinc (Zn) clustered near copper, suggesting high solubility, whereas molybdenum (Mo), vanadium (V), and titanium (Ti) appeared more distant. A Pareto analysis confirmed that Ar and En accounted for over 60% of the explained variance.

Distances between each element and Cu were computed using the correlation-based metric. These distances showed strong qualitative agreement with known empirical solubility trends.

Table 1. Predictors and Solubility Data for Selected Elements

Element	Atomic Radius (pm)	Electronegativity	Distance to Cu	Empirical Solubility	Model Prediction
Pd	137	2.20	0.08	High	High
Mo	140	2.16	0.35	Low	Low
Ti	147	1.54	0.41	Low	Low

Cr	128	1.66	0.31	Medium	Low
V	134	1.63	0.29	Medium	Low

Limitations and Future Work.

Despite the encouraging results, the current model is limited by the relatively small dataset and lack of direct experimental validation. To address these limitations, future work will focus on:

- Expanding the dataset to include ternary systems and experimental solubility measurements;
- Integrating thermodynamic descriptors such as mixing enthalpy (ΔH_{mix}), atomic size mismatch (δ), and the Ω parameter;
- Exploring nonlinear dimensionality reduction techniques (e.g., t-SNE, UMAP);
- Applying supervised machine learning algorithms (e.g., support vector machines, random forest) for enhanced prediction accuracy.

Relevance to the European Scientific Space

This research supports Ukraine's scientific integration within the European Research Area by contributing to the field of AI-driven materials design. It aligns with the goals of Horizon Europe by promoting transparency, data sharing, and the development of open-access predictive models in the context of sustainable and innovative alloy development.

Conclusions:

1. PCA enables objective dimensionality reduction and improves model interpretability.
2. Atomic radius and electronegativity are key predictors of impurity solubility in copper alloys.
3. Correlation-based distance metrics offer superior performance compared to traditional Euclidean methods in capturing chemical affinities.
4. The proposed model lays a strong foundation for integrating additional thermodynamic and experimental parameters in future solubility prediction tools.

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OPTIMISATION OF QUEUE MANAGEMENT IN COGNITIVE RADIO NETWORKS

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Abstract. The article focuses on analyzing ooptimisation of queue management, which reduces delays and improves the quality of service for secondary users. The results showed that the use of dynamic queue management methods significantly reduces delays, which is especially important for networks with interactive traffic such as VoIP and video streaming.

Keywords: cognitive radio network, network traffic, quality of service, flow, communication channel, resource management, load balancing, computer network.

Cognitive Radio Networks (CRNs) are a key technology for efficient use of the radio spectrum [1]. Secondary Users (SUs) can occupy the spectrum only in the absence of Primary Users (PUs), which leads to unstable access and accumulation of packet queues. The main problem is to optimize queue management, to minimize delays, and improve quality of service (QoS).

The queue in a CRN can be represented as a mass-service system, where the service time of SUs depends on the activity of PUs [2]. Using the M/M/1 model, the average packet waiting time in the queue is given by:

$$W = \frac{1}{\mu - \lambda},$$

where λ is the intensity of the incoming request flow, μ is the intensity of the service.

For cognitive networks, two operating modes should be considered: available spectrum (ON) and unavailable (OFF), which can be modeled as a Markov