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ECONOMIC EFFICIENCY ANALYSIS OF A CORROSION INHIBITOR SYNTHESIZED FROM LINEAR ALKYLBENZENE SULFONIC ACID, UREA, AND PHOSPHORIC ACID FOR THE OIL AND GAS INDUSTRY

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Abstract. Corrosion of metallic equipment in acidic environments causes significant economic losses in the oil and gas sector. This paper presents an economic efficiency analysis of a recently synthesized corrosion inhibitor obtained from linear alkylbenzene sulfonic acid (LABSA), urea, and phosphoric acid, designated bis(ammonium)urea dodecylbenzenesulfonate dihydrogen phosphate salt (BDDP). The inhibitor is prepared from locally available raw materials in a simple four-stage process with a 92% yield and exhibits a corrosion protection efficiency of up to 93.2% in 15% hydrochloric acid at a dosage of 300 mg/L, with an experimentally determined molecular weight of 488.1 g/mol. Using current market prices, the raw-material cost of producing one tonne of the inhibitor was calculated at approximately 10.94 million UZS (≈ 10,942 UZS/kg), and the total ex-works production cost at approximately 14.49 million UZS per tonne. Compared with imported analogues (Pachem-C101 and PuRO-Tech iChem 1011 A, priced at ≈ 24.59 and ≈ 29.56 million UZS per tonne), the synthesized inhibitor is roughly 2–3 times cheaper, confirming its strong import-substitution and commercialization potential.

Keywords: corrosion inhibitor, LABSA, urea, phosphoric acid, economic efficiency, cost analysis, import substitution, oil and gas.

Аннотация. Коррозия металлического оборудования в кислотных средах приводит к значительным экономическим потерям в нефтегазовом секторе. В данной работе представлен анализ экономической эффективности недавно синтезированного ингибитора коррозии, полученного из линейной алкилбензолсульфоновой кислоты (ЛАБСК), мочевины и фосфорной кислоты и обозначенного как соль бис(аммоний)мочевины

ISSN 3030-3907

додецилбензолсульфоната дигидрофосфата (BDDP). Ингибитор получают из местного доступного сырья в простом четырёхстадийном процессе с выходом 92% ; он проявляет эффективность противокоррозионной защиты до 93,2% в 15%-ной соляной кислоте при дозировке 300 мг/л и имеет экспериментально определённую молекулярную массу 488,1 г/моль. На основе текущих рыночных цен стоимость сырья для производства одной тонны ингибитора рассчитана приблизительно в 10,94 млн сум (≈ 10 942 сум/кг), а полная себестоимость производства на условиях франко-завод — приблизительно в 14,49 млн сум за тонну. По сравнению с импортными аналогами (Pachem-C101 и PuRO-Tech iChem 1011 A стоимостью ≈ 24,59 и ≈ 29,56 млн сум за тонну) синтезированный ингибитор примерно в 2–3 раза дешевле, что подтверждает его значительный потенциал импортозамещения и коммерциализации.

Ключевые слова: ингибитор коррозии, ЛАБСК, мочевина, фосфорная кислота, экономическая эффективность, анализ затрат, импортозамещение, нефть и газ.

Annotatsiya. Kislotali muhitda metall uskunalarning korroziyasi neft-gaz sohasida sezilarli iqtisodiy yo‘qotishlarga olib keladi. Ushbu ishda chiziqli alkilbenzolsulfon kislotasi (LABSK), karbamid va fosfor kislotasidan olingan va bis(ammoniy) tuzi sifatida belgilangan yangi sintezlangan korroziya ingibitorining iqtisodiy samaradorligi tahlil qilingan.karbamid dodetsilbenzolsulfonat dihidrogenfosfat (BDDP). Inhibitor mahalliy mavjud xomashyodan oddiy to‘rt bosqichli jarayonda 92% hosil bilan olinadi; U 300 mg/l dozada 15% li xlorid kislotada 93,2% gacha korroziyaga qarshi himoya samaradorligini namoyon etadi va eksperimental tarzda aniqlangan molekulyar massasi 488,1 g/mol ga teng. Joriy bozor narxlari asosida bir tonna ingibitor ishlab chiqarish uchun xomashyo qiymati taxminan 10,94 million so‘m (≈ 10 942 so‘m/kg), zavod shartlarida ishlab chiqarishning to‘liq tannarxi esa taxminan 14,49 million so‘m/tonna deb hisoblandi. Import qilingan analoglar bilan taqqoslaganda (pachem-C101 va puro-Tech iChem 1011 a qiymati ≈ 24,59 va ≈ 29,56 million so'm / tonna) sintez qilingan Inhibitor taxminan 2-3 baravar arzon, bu uning import o'rnini bosish va tijoratlashtirish imkoniyatlarini tasdiqlaydi.

Kalit so‘zlar: korroziya ingibitori, LABSK, karbamid, fosfor kislotasi, iqtisodiy samaradorlik, xarajatlar tahlili, import o‘rnini bosish, neft va gaz.

1. INTRODUCTION.

Corrosion is the degradation of metals through chemical or electrochemical interaction with their environment, and it leads to substantial economic losses in industry. Pipelines, storage tanks, heat exchangers, and other equipment operating in acidic media, such as the hydrochloric acid solutions used in well acidizing, are

ISSN 3030-3907

particularly vulnerable. Corrosion inhibitors are the most practical and cost-effective means of slowing this destructive process.

In recent years, attention has shifted toward environmentally safe, inexpensive, and water-soluble inhibitors based on novel components, as many traditional inhibitors contain heavy metals or chlorinated organic compounds that restrict their use. A novel inhibitor synthesized from LABSA, urea, and phosphoric acid (BDDP) was recently reported to combine high inhibitive performance with synthesis from locally available raw materials [1]. While its synthesis and anti-corrosion properties have been characterized, a detailed assessment of its production economics is required to judge its industrial viability. The present work therefore evaluates the economic efficiency of producing the BDDP inhibitor from local raw materials and compares its cost with that of imported analogues.

2. MATERIALS AND METHODS.

The inhibitor was synthesized from LABSA (97%), urea (99%), phosphoric acid (85%), and distilled water in four stages under simple laboratory conditions, yielding a brown, homogeneous, water-soluble viscous liquid with a reaction yield of 92% [1]. The molecular weight was determined by the cryoscopic method, and the inhibitive performance was evaluated gravimetrically on mild-steel coupons immersed for 300 hours in 15% HCl at inhibitor dosages of 100–300 mg/L; the protection efficiency (Z) and corrosion rate were obtained from the mass-loss data.

For the economic assessment, the raw-material requirement per tonne of product was obtained by scaling the laboratory synthesis recipe (LABSA : urea : 85% phosphoric acid : water = 400 : 200 : 150 : 100 by mass). Unit prices reflect international market data for the period Q4 2025–Q2 2026 (LABSA ≈ USD 1,300/t; urea ≈ USD 400/t; 85% phosphoric acid ≈ USD 1,000/t), converted to Uzbek som at the June 2026 reference rate of ≈ 12,100 UZS/USD. The total production cost was then built up from materials, labour, social contributions, overheads, and contingency, with taxes (7%) and profit (5%) added in accordance with standard cost-accounting practice. Imported-analogue prices were taken from procurement and market data reported for these products.

3. RESULTS AND DISCUSSION.

3.1. Inhibitor identity and performance. The molecular weight of the synthesized compound, determined by the cryoscopic method, was 488.1 g/mol, in close agreement with the theoretical value of 484 g/mol (relative error 0.85%; accuracy 99.15%). Owing to its ionic structure, the compound was named bis(ammonium)urea dodecylbenzenesulfonate dihydrogen phosphate salt

ISSN 3030-3907

(BDDP). The dependence of the corrosion protection efficiency on inhibitor concentration is summarized in Table 1.

Table 1.

Corrosion inhibition efficiency of the synthesized inhibitor (mild steel, 15% HCl, 300 h)

Inhibitor concentration, mg/L	Corrosion rate, K	Protection efficiency, Z (%)
Blank (no inhibitor)	1.31	—
100	0.313	76.1
150	0.255	80.5
200	0.156	88.1
250	0.135	89.7
300	0.085	93.2

The protection efficiency rose steadily with concentration and reached a maximum of 93.2% at 300 mg/L, confirming the high inhibitive performance that underpins the economic case for the product.

3.2. Raw-material cost. The raw-material cost of producing one tonne of the inhibitor is detailed in Table 2. The calculated value of ≈ 10.94 million UZS per tonne (≈ 10,942 UZS/kg) is fully consistent with the previously reported figure of approximately 11,000 UZS/kg [1].

Table 2.

Raw-material cost for producing 1 tonne of the BDDP inhibitor

Raw material	Unit price, UZS/kg	Amount per 1 t, kg	Cost, UZS
LABSA (97%)	16,000	470.6	7,529,600
Urea (99%)	5,000	235.3	1,176,500
Phosphoric acid (85%)	12,000	176.5	2,118,000
Distilled water	1,000	117.6	117,600
Total	—	**1,000.0**	**10,941,700**

3.3. Production cost structure. Adding labour, overheads, taxes, and profit to the raw-material cost gives the full ex-works production cost shown in Table 3. The total cost is approximately 14.49 million UZS per tonne (≈ 14,490 UZS/kg, or about USD 1,198/t).

ISSN 3030-3907

Table 3.

Production cost structure for 1 tonne of the BDDP inhibitor

Cost item	Cost, UZS
Raw materials	10,941,700
Labour (wages)	800,000
Social contributions (12%)	96,000
Overheads (energy, equipment, utilities)	890,000
Contingency	210,000
Production cost (subtotal)	**12,937,700**
Taxes (7%)	905,639
Profit (5%)	646,885
Total ex-works cost	**14,490,224**

3.4. Comparison with imported analogues. Table 4 compares the cost of the BDDP inhibitor with two imported products commonly used in the oil and gas sector. On a total-cost basis the synthesized inhibitor is about 41% cheaper than Pachem-C101 and about 51% cheaper than PuRO-Tech iChem 1011 A; on a raw-material basis it is roughly 2.2–2.7 times cheaper, in line with the reported 2–3-fold advantage over global market prices.

Table 4.

Cost comparison of the BDDP inhibitor with imported analogues (per tonne)

Inhibitor	Cost, mln UZS/t	UZS/kg	≈ USD/t
BDDP — raw materials	10.94	10,942	≈ 904
BDDP — total ex-works	14.49	14,490	≈ 1,198
Pachem-C101 (imported)	24.59	24,587	≈ 2,032
PuRO-Tech iChem 1011 A (imported)	29.56	29,558	≈ 2,443

3.5. Economic and strategic advantages. Beyond its low production cost, the inhibitor offers several economic and strategic benefits. It is synthesized from locally available raw materials, reducing dependence on imports and supporting domestic production. The four-stage process requires no complex equipment, making it suitable for scale-up. By extending the service life of metal structures,

ISSN 3030-3907

the inhibitor lowers maintenance and replacement expenditure, while its water solubility and low toxicity favour environmentally responsible application.

4. CONCLUSION.

The synthesized inhibitor BDDP combines high corrosion protection (up to 93.2% in 15% HCl) with a low production cost — approximately 10.94 million UZS per tonne for raw materials and about 14.49 million UZS per tonne in total. This is roughly 2–3 times cheaper than imported analogues such as Pachem-C101 and PuRO-Tech iChem 1011 A. Together with its synthesis from local raw materials, simple production process, and environmental safety, these results indicate that the inhibitor is an economically attractive and strategically significant product for corrosion protection in the oil and gas industry, with clear import-substitution potential.

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