# DYNAMIC VISCOSITIES OF n-BUTYRALDEHYDE AND ISOBUTYRALDEHYDE AT VARIOUS TEMPERATURES AND PRESSURES

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New experimental data are presented on the dynamic viscosity of n-butyraldehyde and isobutyraldehyde at 293.53-501.88°K and 0.1-49.1 MPa.

n-Butyraldehyde and isobutyraldehyde are secondary products in the production of butanol and isobutanol and various organic acids.

These aldehydes are widely used in the chemical industry, so we have examined their viscosities over wide ranges in temperature and pressure. The dynamic viscosity was measured with a system based on the capillary method, with the use of a viscometer due to Golubev [1]. The viscosity was measured in the temperature range 293.53-501.88°K and the pressure range 0.1-49.1 MPa. The basic dimensions of the viscometer (at room temperature) were as follows: capillary radius, $r = 1.1 \cdot 10^{-4}$ m; length of capillary, $l = 905 \cdot 10^{-4}$ m; volume of measuring bulb, $v = 214.13 \cdot 10^{-4}$ m$^3$. The geometrical dimensions of the viscometer were determined with an MIR-12 microscope and a KM-8 cathetometer by the method of [2].

The working temperature (in the zone of the capillary) was determined with a PTS-10 platinum resistance thermometer and was monitored with a Chromel—Alumel thermocouple, while the pressure was produced and measured with an MP-600 piston-load manometer of accuracy class 0.05. The viscometer was thermostatted at 24°C with an error of ±0.05°C. The time of flow through the capillary was measured automatically with a P14M chronometer with an error of ±0.01 sec. The aldehydes were purified by the method of [3] and were stored in a cool dark place. The purities of the n-butyraldehyde and isobutyraldehyde were, respectively, 99.97 and 99.98% by mass (PAI chromatograph). When the apparatus was

TABLE 1. Dynamic Viscosities of Aldehydes (smoothed with respect to pressure), $10^6$ Pa·sec

| $T$, K | $P$, MPa | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0,1 | 5,0 | 9,9 | 19,7 | 29,5 | 39,3 | 49,1 |
| n-Butyraldehyde | | | | | | | |
| 295,08 | 460 | 482 | 502 | 541 | 576 | 617 | 656 |
| 318,13 | 373 | 388 | 405 | 436 | 465 | 495 | 523 |
| 333,43 | 332 | 346 | 361 | 388 | 414 | 439 | 465 |
| 365,73 | — | 289 | 301 | 322 | 346 | 364 | 384 |
| 398,98 | — | 252 | 264 | 282 | 298 | 317 | 335 |
| 425,48 | — | 232 | 241 | 260 | 276 | 293 | 311 |
| 455,13 | — | 216 | 225 | 243 | 260 | 277 | 295 |
| 495,13 | — | 204 | 213 | 231 | 258 | 264 | 282 |
| Isobutyraldehyde | | | | | | | |
| 293,53 | 447 | 463 | 486 | 526 | 265 | 605 | 648 |
| 313,28 | 365 | 382 | 398 | 430 | 462 | 495 | 527 |
| 333,43 | 315 | 328 | 342 | 368 | 394 | 422 | 445 |
| 364,13 | — | 281 | 292 | 312 | 330 | 352 | 374 |
| 393,63 | — | 249 | 259 | 273 | 288 | 305 | 324 |
| 435,13 | — | 216 | 227 | 237 | 252 | 267 | 281 |
| 457,08 | — | 202 | 212 | 225 | 238 | 252 | 264 |
| 501,88 | — | 176 | 187 | 201 | 216 | 228 | 242 |

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filled, precautions were taken to prevent contact of the aldehydes with air. The error in the viscosity measurement was ±1%. We recorded 101 values of the dynamic viscosity (Table 1). We used the P—V—T data for the aldehydes from [4] in calculating the dynamic viscosity.

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# PROBLEMS IN DESIGN AND CONSTRUCTION OF CURRENT INPUT LEADS MADE OF POROUS MATERIALS FOR CRYOGENIC ELECTRICAL EQUIPMENT

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Peculiarities in the design of porous current input leads are considered, such leads being cooled by axial filtration of a one-phase stream of a coolant, and a complex analysis of the heat transfer as well as the hydrodynamics involved here is presented in a more elementary form.

Current input leads are used for feeding an electric current from the "warm" region to cryogenic cables, windings of electrical machines, superconducting solenoids, electromagnets, energy storing devices, etc. [1-18].

In short cables (on the order of 1000 m long) the losses on cooling the current leads can, according to this author's estimates, exceed 50% of the total energy loss. The current lead often determines the reliability and the economics of the entire superconducting system [2].

One of the promising trends in development of economical and reliable gas-cooled current leads is the use of compact structures with a large heat-exchange surface, particularly porous conductors and electrical insulation [1, 11-17]. As porous current conductors, one can use ropes, braids, and meshes made of metallic electrically conducting materials, bundles of thin-walled capillaries, stacks of thin foil (perforated and corrugated, if possible), electrically conducting ceramics produced from metal powder by sintering, busbars made of microconductors in the form of a metallic "felt," metallic "foams," and combinations of any of these.

Practical experience in using porous current leads for superconducting devices testifies to their highly efficient performance [1, 11-17]. Current leads built with porous elements are very compact and ensure a high degree of utilization (80-100%) of the coolant enthalpy with very little thermal inertia. With porous current leads it is possible to vary their performance parameters over a wider range, owing to their wide range of thermophysical and electrophysical characteristics, also by varying the porosity and the permeability of the structural materials. Individual segments of current leads can be supplied with the necessary liquid coolant by forces of capillary suction. Difficulties in the practical application of porous current leads are related primarily to hydrodynamic losses, which become high when a coolant filtrates through a low-permeability material ($k < 10^{-10}$ m$^2$) [16], and to problems in producing agglomerate structures with ideal contact between particles.

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